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ABSTRACT

This curriculum guide is part of a series designed to teach students about diesel engines. The materials in this power trains guide apply to both on-road and off-road vehicles and include information about chain and belt drives used in tractors and combines. These instructional materials, containing nine units, are written in terms of student performance using measurable objectives. Each instructional unit includes some or all of the basic components of a unit of instruction: performance objectives, suggested activities for teachers and students, information sheets, assignment sheets, job sheets, visual aids, tests, and answers to the tests. Lessons are illustrated with industry-generated illustrations and units are planned for more than one lesson or class period of instruction. The nine units cover the following topics: introduction to power trains, clutches and flywheels, torque converters and fluid drives, mechanical transmissions, automatic transmissions, drive lines, differentials and final drives, power take-offs, and special drives. (KC)

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POWER TRAINS

By

Marvin Kukuk

and

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Developed by the

Mid-America Vocational Curriculum Consortium, Inc.

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POWER TRAINS
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FOREWORD

Power Trains is another splendid example of the ten Mid-America Vocational Curriculum Consortium States working together. Through its process of assembling regional expertise, MAVCC set out to produce a curriculum that would truly reflect contemporary needs of the diesel mechanics industry. This involved a rewrite and update of *Diesel Engine Mechanics* first published in 1977. The original diesel text has been expanded to three: *Diesel Mechanics: Fundamentals*, *Diesel Mechanics: Electrical Systems*, and *Diesel Mechanics: Fuel Systems*. MAVCC's *Hydraulics* was designed to supplement diesel training programs, and now, *Power Trains* is available to provide further continuity in student training.

The success of this publication is due, in large part, to the capabilities of the personnel who worked with its development. The technical writers have numerous years of industry as well as teaching experience. Assisting them in their efforts were representatives of each of the member states who brought with them technical expertise and the experience related to the classroom and to the trade. To assure that the materials would parallel the industry environment and be accepted as a transportable basic teaching tool, organizations and industry representatives were involved in the developmental phases of the manual. Appreciation is extended to them for their valuable contributions to the manual.

Instructional materials in this publication are written in terms of student performance using measurable objectives. This is an innovative approach to teaching that accents and augments the teaching/learning process. Criterion referenced evaluation instruments are provided for uniform measurement of student progress. In addition to evaluating recall information, teachers are encouraged to evaluate the other areas including process and product as indicated at the end of each instructional unit.

It is the sincere belief of the MAVCC personnel and all those members who served on the committees that this publication will allow the students to become better prepared and more effective members of the work force.

David Poston, Chairman
Board of Directors
Mid-America Vocational
Curriculum Consortium

PREFACE

You can't please everybody all of the time, but *Power Trains* certainly comes close. The materials apply to both on-road and off-road vehicles with special materials for PTOs and chain and belt drives used in tractors and combines. We feel that instructors who have been waiting for *Power Trains* will find the text is worth its "wait" in gold.

MAVCC is insistent that its materials reflect industry needs and industry standards. *Power Trains* fulfills both requirements in the traditional easy-to-teach from, easy-to-learn from format. Best of all, *Power Trains* has job sheet after job sheet after job sheet for extensive hands-on student learning activity. And thanks to General Motors, Ford, John Deere, Eaton, Rockwell International, Caterpillar, and other major manufacturers of power train components, the text has a profusion of excellent illustrations that will serve to reinforce and enhance both teaching and learning.

We plan carefully and edit with dedication, but we're still subject to typographical errors and other possible errors in content. When you take time to call or write us when changes or improvements should be made, that makes you part of the MAVCC team--we welcome criticism from instructors who use our texts. Your observations can contribute positively to update and revision, and we hope you keep in touch.

Students studying diesel engines are learning how to keep 'em running. *Power Trains* is here to help students learn to keep 'em rolling. Have a good trip.

Ann Benson
Executive Director
Mid-America Vocational
Curriculum Consortium

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Appreciation is extended to the many dedicated people who contributed their time and expertise to the development of *Power Trains*.

Members of the MAVCC Resource Committee that planned and reviewed the contents of this publication are:

Cliff Olson	Devils Lake, North Dakota
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Ted Modica	Albuquerque, New Mexico
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Jim Thompson	Beloit, Kansas
Bill August	Milford, Nebraska
Darwin Hutzell	Austin, Texas

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Gratitude is expressed to Dan Fulkerson for editing and to Mary Kellum, Jane Huston, and P. J. Colbert for their assistance in editing and proofreading.

The Graphics Division of the Oklahoma State Department of Vocational and Technical Education is deserving of much credit for typing, providing artwork, and printing this publication.

USE OF THIS PUBLICATION

Instructional Units

Power Trains includes nine units. Each instructional unit includes some or all of the basic components of a unit of instruction: performance objectives, suggested activities for teachers and students, information sheets, assignment sheets, job sheets, visual aids, tests, and answers to the test. Units are planned for more than one lesson or class period of instruction.

Careful study of each instructional unit by the teacher will help to determine:

- A. The amount of material that can be covered in each class period
- B. The skills which must be demonstrated
 - 1. Supplies needed
 - 2. Equipment needed
 - 3. Amount of practice needed
 - 4. Amount of class time needed for demonstrations
- C. Supplementary materials such as pamphlets or filmstrips that must be ordered
- D. Resource people who must be contacted

Objectives

Each unit of instruction is based on performance objectives. These objectives state the goals of the course, thus providing a sense of direction and accomplishment for the student.

Performance objectives are stated in two forms: unit objectives, stating the subject matter to be covered in a unit of instruction; and specific objectives, stating the student performance necessary to reach the unit objective.

Since the objectives of the unit provide direction for the teaching-learning process, it is important for the teacher and students to have a common understanding of the intent of the objectives. A limited number of performance terms have been used in the objectives for this curriculum to assist in promoting the effectiveness of the communication among all individuals using the materials.

Following is a list of performance terms and their synonyms which may have been used in this material:

<u>Name</u>	<u>Identify</u>	<u>Describe</u>
Label	Select	Define
List in writing	Mark	Discuss in writing
List orally	Point out	Discuss orally
Letter	Pick out	Interpret
Record	Choose	Tell how
Repeat	Locate	Tell what
Give	Label	Explain

Order
 Arrange
 Sequence
 List in order
 Classify
 Divide
 Isolate
 Sort

Distinguish
 Discriminate
 Differentiate

Construct
 Draw
 Make
 Build
 Design
 Formulate
 Reproduce
 Transcribe
 Reduce
 Increase
 Figure

Demonstrate
 Show your work
 Show procedure
 Perform an experiment
 Perform the steps
 Operate
 Remove
 Replace
 Turn off/on
 (Dis) assemble
 (Dis) connect

Additional Terms Used
 Evaluate
 Complete
 Analyze
 Calculate
 Estimate
 Plan
 Observe
 Compare
 Determine
 Perform

Prepare
 Make
 Read
 Tell
 Teach
 Converse
 Lead
 State
 Write

Reading of the objectives by the student should be followed by a class discussion to answer any questions concerning performance requirements for each instructional unit.

Teachers should feel free to add objectives which will fit the material to the needs of the students and community. When teachers add objectives, they should remember to supply the needed information, assignment and/or job sheets, and criterion tests.

Suggested Activities for the Instructor:

Each unit of instruction has a suggested activities sheet outlining steps to follow in accomplishing specific objectives. Duties of instructors will vary according to the particular unit; however, for best use of the material they should include the following: provide students with objective sheet, information sheet, assignment sheets, and job sheets; preview filmstrips, make transparencies, and arrange for resource materials and people; discuss unit and specific objectives and information sheet; give test. Teachers are encouraged to use any additional instructional activities and teaching methods to aid students in accomplishing the objectives.

Information Sheets

Information sheets provide content essential for meeting the cognitive (knowledge) objectives in the unit. The teacher will find that the information sheets serve as an excellent guide for presenting the background knowledge necessary to develop the skill specified in the unit objective.

Students should read the information sheets before the information is discussed in class. Students may take additional notes on the information sheets.

Transparency Masters

Transparency masters provide information in a special way. The students may see as well as hear the material being presented, thus reinforcing the learning process. Transparencies may present new information or they may reinforce information presented in the information sheets. They are particularly effective when identification is necessary.

Transparencies should be made and placed in the notebook where they will be immediately available for use. Transparencies direct the class's attention to the topic of discussion. They should be left on the screen only when topics shown are under discussion.

Job Sheets

Job sheets are an important segment of each unit. The instructor should be able to and in most situations should demonstrate the skills outlined in the job sheets. Procedures outlined in the job sheets give direction to the skill being taught and allow both student and teacher to check student progress toward the accomplishment of the skill. Job sheets provide a ready outline for students to follow if they have missed a demonstration. Job sheets also furnish potential employers with a picture of the skills being taught and the performances which might reasonably be expected from a person who has had this training.

Assignment Sheets

Assignment sheets give direction to study and furnish practice for paper and pencil activities to develop the knowledges which are necessary prerequisites to skill development. These may be given to the student for completion in class or used for homework assignments. Answer sheets are provided which may be used by the student and/or teacher for checking student progress.

Test and Evaluation

Paper-pencil and performance tests have been constructed to measure student achievement of each objective listed in the unit of instruction. Individual test items may be pulled out and used as a short test to determine student achievement of a particular objective. This kind of testing may be used as a daily quiz and will help the teacher spot difficulties being encountered by students in their efforts to accomplish the unit objective. Test items for objectives added by the teacher should be constructed and added to the test.

Test Answers

Test answers are provided for each unit. These may be used by the teacher and/or student for checking student achievement of the objectives.

POWER TRAINS
INSTRUCTIONAL/TASK ANALYSIS

JOB TRAINING: What the
Worker Should Be Able To Do
(Psychomotor)

RELATED INFORMATION:
What the Worker Should Know
(Cognitive)

UNIT I: INTRODUCTION TO POWER TRAINS

1. Terms and definitions
2. Basic components of a power train and their functions
3. Sequence for the transmission of power through a power train
4. Working applications of power trains
5. Types of gears found in power trains
6. Formula for calculating gear ratios
7. How to determine gear rotation
8. Formula for calculating gear speed
9. Calculate gear ratio
10. Calculate gear rotation
11. Calculate gear speed

JOB TRAINING: What the
Worker Should Be Able to Do
(Psychomotor)

RELATED INFORMATION:
What the Worker Should Know
(Cognitive)

UNIT II: CLUTCHES AND FLYWHEELS

1. Terms and definitions
2. Components of a basic clutch assembly
3. Parts of a flywheel
4. Functions of a flywheel
5. Parts of a dry-type disc clutch
6. Types of clutches and their descriptions
7. Types of pressure plates
8. Difference between a disengaged and an engaged clutch
9. Clutch linkage mechanisms and their functions
10. Conditions to look for during clutch inspection
11. Symptoms that occur when a clutch housing bore has excessive runout
12. Clutch malfunctions and probable causes
13. Purposes of a dual disc clutch
14. Adjust clutch linkage free travel
15. Adjust free travel on a pull type clutch
16. Remove a clutch assembly

**JOB TRAINING: What the
Worker Should Be Able to Do
(Psychomotor)**

17. Inspect a clutch disc
18. Check a clutch housing alignment
19. Inspect a pressure plate and cover
20. Inspect a pilot bearing and pilot bushing
21. Reinstall a clutch assembly
22. Remove, inspect, repair, and reinstall a 15 1/2-inch dual disc clutch
23. Disassemble, inspect, and reassemble a hydraulic (wet-type) clutch
24. Check flywheel runout
25. Remove and replace a flywheel ring gear

**RELATED INFORMATION:
What the Worker Should Know
(Cognitive)**

UNIT III: TORQUE CONVERTERS AND FLUID DRIVES

1. Terms and definitions
2. How a basic fluid coupling works
3. Parts of a torque converter
4. Torque converter parts and their functions
5. Types of fluid flow in torque converters and their characteristics
6. Operation of a twin-turbine torque converter
7. Operation of a lockup clutch converter

**JOB TRAINING: What the
Worker Should Be Able to Do
(Psychomotor)**

8. Drain and refill a torque converter
9. Check for oil leaks
10. Test a torque converter

**RELATED INFORMATION:
What the Worker Should Know
(Cognitive)**

UNIT IV: MECHANICAL TRANSMISSIONS

1. Terms and definitions
2. Types of mechanical transmissions
3. Parts of a sliding gear transmission
4. Parts of a sliding clutch transmission top shaft
5. Parts of a front section countershaft
6. Parts of a transmission front section case with clutch housing
7. Parts of an auxiliary section of a ten speed transmission
8. Parts of a shift lever housing and reverse stop plunger
9. Parts of a shift bar housing
10. Parts of a remote shift control assembly
11. Air flow for range shifting

**JOB TRAINING: What the
Worker Should Be Able to Do
(Psychomotor)**

12. Indicate air flow in air lines
for range shifting
13. Check a mechanical transmission
fluid level
14. Remove and disassemble a
mechanical transmission
15. Inspect transmission parts
16. Reassemble a mechanical transmission
17. Disassemble a shifting bar
housing
18. Inspect a shifting bar housing
and parts
19. Reassemble a shifting bar
housing
20. Install a mechanical transmission
21. Test a mechanical transmission after
rebuilding

**RELATED INFORMATION:
What the Worker Should Know
(Cognitive)**

UNIT V: AUTOMATIC TRANSMISSIONS

1. Terms and definitions
2. Major parts of an auto-
matic transmission
3. Steps in oil pump and
regulating valve operation
4. Low range, high range,
and reverse range func-
tions in an automatic
transmission
5. Characteristics of auto-
matic transmission fluid
6. Procedure for properly
checking automatic trans-
mission fluid

**JOB TRAINING: What the
Worker Should Be Able to Do
(Psychomotor)**

18. Remove an automatic transmission from a vehicle
19. Disassemble an automatic transmission into subassemblies

**RELATED INFORMATION:
What the Worker Should Know
(Cognitive)**

7. In-vehicle transmission tests and their functions
8. Parts of a planetary gear system
9. Planetary gear system operation
10. Speed, torque, and directional functions of an automatic transmission and ways they are accomplished
11. Tools and equipment required for automatic transmission overhaul
12. Parts normally replaced at each automatic transmission overhaul
13. Important elements of cleaning and inspection
14. Special considerations for bearing inspection and handling
15. Transmission components and their inspection requirements
16. Make-ready procedures for removing or installing an automatic transmission
17. General rules for determining whether to reuse or replace a part

**JOB TRAINING: What the
Worker Should Be Able to Do
(Psychomotor)**

**RELATED INFORMATION:
What the Worker Should Know
(Cognitive)**

20. Check end play on a torque converter assembly
21. Disassemble, clean, and inspect a torque converter assembly
22. Rebuild a stator assembly
23. Reassemble a torque converter assembly
24. Disassemble, clean, inspect, and reassemble a modulated lockup valve assembly
25. Disassemble, clean, inspect, and reassemble a low shift valve assembly
26. Disassemble, clean, inspect, and reassemble a control valve body assembly
27. Disassemble, clean, inspect, and reassemble an oil pump and front support assembly
28. Disassemble, clean, inspect, and reassemble a forward clutch and turbine shaft
29. Disassemble, clean, inspect, and reassemble a fourth clutch
30. Disassemble, clean, inspect, and reassemble a center support assembly
31. Disassemble, clean, inspect, and reassemble a gear unit and main shaft assembly
32. Disassemble, clean, inspect, and reassemble an output shaft
33. Disassemble, clean, inspect, and reassemble a rear cover assembly
34. Disassemble, clean, inspect, and reassemble an adapter housing and first clutch piston
35. Disassemble, clean, inspect, and reassemble a transmission housing
36. Reassemble an automatic transmission

**JOB TRAINING: What the
Worker Should Be Able to Do
(Psychomotor)**

37. Install an automatic transmission
38. Test an automatic transmission
39. Make shift speed adjustments on an automatic transmission

**RELATED INFORMATION:
What the Worker Should Know
(Cognitive)**

UNIT VI: DRIVE LINES

1. Terms and definitions
 2. Two characteristics of a hotchkiss drive
 3. Types of propeller shafts
 4. Parts of a propeller shaft with shift yoke
 5. Parts of a center bearing
 6. Difference between constant velocity and cross and roller U-joints
 7. Parts of a cross and roller U-joint
 8. Points on a drive train to check component angles
 9. Acceleration-deceleration of propeller shaft with cardon U-joints
 10. Problems causing drive line noise or vibration
-
11. Remove and replace a propeller shaft
 12. Disassemble, inspect, and reassemble a U-joint with bolted end

**JOB TRAINING: What the
Worker Should Be Able to Do
(Psychomotor)**

13. Remove and replace a cross and roller U-joint
14. Align and time a telescoping drive line
15. Balance a propeller shaft

**RELATED INFORMATION:
What the Worker Should Know
(Cognitive)**

UNIT VII: DIFFERENTIALS AND FINAL DRIVES

1. Terms and definitions
2. Types of differentials and final drives and their definitions
3. Parts of a gear tooth
4. Methods used to evaluate gear tooth contact patterns
5. Parts of a differential
6. Parts of a planetary gearset
7. Planetary gearset components and their characteristics
8. Types of differential locks
9. Purposes of a power divider
10. Basic parts of a power divider
11. Shifting mechanisms and their descriptions
12. Difference between flared and compression fittings

**JOB TRAINING: What the
Worker Should Be Able to Do
(Psychomotor)**

**RELATED INFORMATION:
What the Worker Should Know
(Cognitive)**

13. Remove a differential assembly
14. Disassemble a differential case and gear assembly
15. Clean and inspect a differential case and gear assembly
16. Adjust drive pinion bearing preload
17. Reassemble a differential case and gear assembly
18. Adjust differential bearing preload; check gear backlash and tooth contact pattern
19. Install differential assembly in differential housing
20. Remove, repair, and reassemble a differential carrier and power divider assembly
21. Disassemble a planetary gear assembly outer ends
22. Clean and inspect parts of a planetary axle
23. Reassemble a planetary gear bearing preload
24. Adjust a planetary gear assembly
25. Perform preventive maintenance on differential and final drives
26. Assemble air line with reusable fitting (flared)
27. Assemble air line with compression fittings

**JOB TRAINING: What the
Worker Should Be Able to Do
(Psychomotor)**

**RELATED INFORMATION:
What the Worker Should Know
(Cognitive)**

UNIT VIII: POWER TAKE-OFFS

1. Terms and definitions
2. Safe operation of PTOs
3. Three types of PTO guards and shields
4. Three types of PTO systems
5. ASAE-SAE standards for tractor PTO drives
6. Complaints and causes for noise, heat, and vibration in transmission-mounted PTOs
7. Troubleshooting PTOs for poor work rate
8. Complaints and causes for external oil leaks in PTOs
9. Troubleshooting PTOs for hard shifting
10. Troubleshooting PTOs for jumping out of gear
11. Troubleshooting power shift PTOs
12. Parts of a two-gear, one-speed PTO
13. Components of hydraulic and electric circuits in a power shift PTO
14. Parts of a PTO air shift system

**JOB TRAINING: What the
Worker Should Be Able to Do
(Psychomotor)**

18. Install a transmission-mounted power take-off

**RELATED INFORMATION:
What the Worker Should Know
(Cognitive)**

15. Shifter covers for transmission-mounted PTOs
16. Procedures for lubricating PTO systems
17. Questions that are relevant when selecting the proper PTO

UNIT IX: SPECIAL DRIVES

1. Terms and definitions
2. Three types of chain drives
3. Detachable-line chains
4. Roller chains
5. Silent chains
6. Characteristics of detachable-link chains
7. Characteristics of standard pitch roller chains
8. Characteristics of double pitch roller chains
9. Characteristics of silent chains
10. Principles of chain drives
11. Alignment of sprocket shafts and sprockets
12. Adjustment of chain tension
13. Methods of adjusting chain tension

**JOB TRAINING: What the
Worker Should Be Able to Do
(Psychomotor)**

**RELATED INFORMATION:
What the Worker Should Know
(Cognitive)**

14. Parts of a chain sprocket
15. Stretched chain
16. Lubrication of chains
17. Methods of lubricating chains
18. Repair of chain drives
19. Cleaning chains
20. Three types of belts
21. Factors governing the ability of belts to transmit power
22. Three forms of belt drive arrangements
23. Measurements of belt sections used on combines
24. Adjustable pulleys
25. How to determine the length of a flat belt
26. How to determine the length of a V-belt
27. How to determine pulley sizes and speeds
28. Belt tension
29. Belt care and maintenance
30. Maintenance of pulleys and sheaves
31. Types of gear drives and their uses
32. Methods of lubricating gears

**JOB TRAINING: What the
Worker Should Be Able to Do
(Psychomotor)**

- 43. Compute the length of a flat belt
- 44. Compute the length of a V-belt
- 45. Troubleshoot chain drives
- 46. Troubleshoot belt drives
- 47. Troubleshoot gear drives
- 48. Troubleshoot hydrostatic drives
- 49. Troubleshoot safety mechanisms

**RELATED INFORMATION:
What the Worker Should Know
(Cognitive)**

- 33. Gear backlash
- 34. Types of reciprocating drives and their characteristics
- 35. Maintenance of reciprocating drives
- 36. Hydrostatic drives and their characteristics
- 37. Reversing hydrostatic drives
- 38. Maintenance of hydrostatic drives
- 39. Testing hydrostatic drives
- 40. Functions of a safety release mechanism
- 41. Types of safety release mechanisms and their descriptions
- 42. Maintenance of safety mechanisms

POWER TRAINS

TOOLS AND MATERIALS

The following is an alphabetized list of tools recommended for completing the job sheets in *Power Trains*; manufacturers' service manuals should be consulted for specific tool numbers.

Adjustable work table	Drill, 3/8"
Adjusting ring tool	Drive gear bearing driver
Air blow gun	Drive pinion flange puller
Air hoses	Droplight
Air nozzles	Dust shield installer
Alignment bolts	Engine support stand
Aligning tool or old transmission drive gear	Feeler gauge
Approved cleaning fluid	Fixture stand
Base plate and top plate	Flaring tool
Basic hand tools	Floor jack
Battery cable pliers	Forward clutch clearance gauge
Bearing and gear remover with drive handle	Front support lifter
Bearing installer and drive handle	Funnel
Bearing puller	Gear unit lifter
Belt tension gauge	Guide bolts and headless guide screws
Blue safety tag	Guide studs, 7/16" x 5" long
Bolts and rubber-covered washers	Hand tachometer
Bushing installer	High pressure oil gauges
Brass punch	High-temperature lubricant
Centering band	High-temperature sealer
Center support lifter	Hoist
Chain hoist	Holding plate and holding fixture
Chalk, crayon, or pencil	Hose clamp
Chock blocks	Hydraulic flow meter
Clean transmission fluid	Hydraulic press, 5-ton
Cleaning solvent	Inch-pound spring scale
Clean shop towels	Jack stands
Clearance gauges for first, second, third, and fourth clutches	Large inside snap ring pliers
Clutch adjustment tool	Large outside snap ring pliers
Clutch disc alignment tool	Lockup spring compressor
Compressed air supply	Marking compound
Compressor, compressor base, and base screw	Maul
Converter end play gauge	Measuring tape
Converter leak detector	Medium needle-point snap ring pliers
Creeper	New carrier and cover gaskets
Deep socket set, 1/2" drive	New converter pump flange bolts
Depth micrometer	New converter pump gasket
Dial indicator	New gasket for valve adapter
Differential jack	New lockstrips, four
Differential repair stand	New 3/8-16 x 2 1/4" self-locking bolt and washer
Drain pan	Nonhardening sealer
	Nylon fittings

Oil seal installer and driver handle
 Oil-Soluble grease
 Output shaft lifting tool
 Output shaft oil seal and dust shield
 remover assembly
 Output shaft oil seal puller
 Paint
 Parts cleaning brush
 Piece of 2 x 4
 Pilot bearing remover
 Pilot shaft
 Plastic bag or plastic wrap
 Plug installer
 Press
 Pressure gauge
 Pry bar
 Pull scale
 Rear bearing installer
 Roll of copper tubing
 Roll of soft wire
 Rear seal installer
 Retaining bolt, 5/8-11 x 3.25"
 Ring gear rivet fixture for press
 Rivet remover pin
 Rubber band or soft wire
 Rubber mallet
 Safety glasses
 Seal drivers
 Selector shaft seal installer
 Selector shaft seal remover
 Self-locking anchor bolt
 Shop towels
 Slide hammer
 Small bearing puller
 Small paint brush
 Small strips of steel for weight
 Snap ring gauge
 Socket-head bolts as required
 Socket set, 3/4" drive
 Socket set, 1/2" drive
 Soft hammer
 Solvent
 Solvent container
 Spirit level protractor or
 magnetic base protractor
 Spring compressor and compressor
 base
 Stake tool
 Stator roller retainer
 Steam supply
 Steel shim stock

Straightedge
 Stud driver
 Test tachometer
 Thickness gauge
 Three-strand lifting sling
 Torque converter lifter
 Torque converter retaining
 strap
 Torque wrench adapter
 Torque wrenches, inch-pound,
 100 foot-pound, and 1000
 foot-pound
 Transmission jack
 Transmission overhaul stand
 Tubing cutter
 Tubing, 2 1/2" OD
 Vacuum gauge
 Valve pin installer
 Valve pin remover
 Valve spring compressor
 Washer-head screws as required
 Welding equipment as required
 Wood blocks
 Work bench with vise

INTRODUCTION TO POWER TRAINS UNIT I

UNIT OBJECTIVE

After completion of this unit, the student should be able to identify the basic parts of a power train and discuss how power is transmitted through the power train. The student should also be able to identify types of gears and calculate gear ratio, rotation, and gear speed. This knowledge will be evidenced by correctly performing the procedures outlined in the assignment sheets and by scoring 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms related to power trains with their correct definitions.
2. Match the basic components of a power train with their functions.
3. Arrange in order the sequence for the transmission of power through a power train.
4. Select working applications of power trains.
5. Select types of drives found in power trains.
6. Identify types of gears found in power trains.
7. Solve problems using the formula for calculating gear ratios.
8. Solve problems concerning how to determine gear rotation.
9. Solve problems using the formula for calculating gear speed.
10. Demonstrate the ability to:
 - a. Calculate gear ratio.
 - b. Calculate gear rotation.
 - c. Calculate gear speed.

INTRODUCTION TO POWER TRAINS UNIT I

SUGGESTED ACTIVITIES

- I. Provide student with objective sheet.
- II. Provide student with information and assignment sheets.
- III. Make transparencies.
- IV. Discuss unit and specific objectives.
- V. Discuss information and assignment sheets.
- VI. Have students make posters for formulas on gear ratio, rotation, and R.P.M. of gears.
- VII. Take students on a field trip to a manufacturer of power train components.
- VIII. Have a mechanic or speaker from industry come in to talk to students about power trains.
- IX. Find films and charts showing different power train components.
- X. Give test.

INSTRUCTIONAL MATERIALS

- I. Included in this unit:
 - A. Objective sheet
 - B. Information sheet
 - C. Transparency masters
 1. TM 1--Basic Power Train Components
 2. TM 2--Types of Gears
 3. TM 3--How Gears Change Direction of Rotation
 4. TM 4--How Gears are Used to Change Speed
 - D. Assignment sheets
 1. Assignment Sheet #1--Calculate Gear Ratio
 2. Assignment Sheet #2--Calculate Gear Rotation
 3. Assignment Sheet #3--Calculate Gear Speed

E. Answers to assignment sheets

F. Test

G. Answers to test

II. References:

- A. *Fundamentals of Service: Power Trains*. Moline, IL 61265: John Deere Service Publications, Dept. F, 1972.
- B. *Service Manuals-RT Series*. Kalamazoo, MI 49007: Eaton Corporation, Transmission Division, 1974.
- C. *Truck Axles, Parts Book EA-107*. Henderson, KY 42420: Eaton Corporation, 1974.
- D. *Spicer 50-60 Series, 5-Speed Transmission Service Manual*. Toledo, OH 43696: Dana Corporation, 1978.
- E. *Truck Talk*. Chicago, IL 60611: International Harvester Co., 1977.
- F. Guynes, Bill. *Diesel Mechanics: Fundamentals*. Stillwater, OK 74074: Mid-America Vocational Curriculum Consortium (MAVCC), 1982.

(NOTE: The above reference, especially Section B, Units V and VI, is a good source for information on seals and bearings. One should also check various manufacturers' specifications.)

INTRODUCTION TO POWER TRAINS UNIT I

INFORMATION SHEET

I. Terms and definitions

- A. Power train--Revolving components involved in the transmission of power from the engine to the drive wheels
- B. Gear ratio--The number of revolutions the driving gear must make to turn the driven gear one revolution
- C. Torque--A turning or twisting force
- D. Backlash--The clearance or play between two gears in mesh
- E. Endplay--End-to-end movement in a gear shaft due to bearing clearances
- F. Preload--Adjustment of antifriction bearings so that they are under mild pressure; tested by the amount of torque in inch pounds required to turn the shaft
- G. Gear reduction--A combination of gears used to reduce the input speed to a lower output speed
- H. Constant mesh--Gears that are always in mesh with each other
- I. Splines--Multiple keys in the general form of internal and external gear teeth, used to prevent rotation of a shaft
- J. Auxiliary transmission--A unit mounted behind the main transmission to provide supplemental gearing

(NOTE: This provides greater reduction, closer splits, or an overdrive.)

II. Basic components of a power train and their functions (Transparency 1)

- A. Flywheel--A rotating metal disc on the rear end of a crankshaft designed to even out power surges during power strokes and deliver energy back during other strokes
- B. Clutch--A device that connects or disconnects a power source from the part it operates to provide a smooth transmission of torque to working parts in movement
- C. Transmission--A device in a power train that increases torque by changing gear ratios, permitting a vehicle to move at varying speeds in both forward and reverse
- D. Drive line--Components that transmit torque from the transmission to the differential; made up of one or more drive shafts with universal and slip joints

INFORMATION SHEET

- E. Differential--A mechanism that drives both rear wheels at the same time but permits the wheels to turn at different speeds so the vehicle can turn corners
 - F. Final drive--The last phase of a power train; it gives final reduction in speed and increase in torque to the drive wheels
- III. Sequence for the transmission of power through a power train (Transparency 1)
- A. Power from engine is transmitted to flywheel
 - B. Clutch is bolted to flywheel to send power to transmission
 - C. Power is transmitted from clutch through transmission at various speeds
 - D. The power comes out of transmission to drive line
 - E. Drive line sends the power to the differential by the pinion and ring gear
 - F. The differential puts the power out to the final drive
- IV. Working applications of power trains
- A. Trucks (highway and off-road)
 - B. Industrial and off-road equipment
 - C. Marine
 - D. Power generators
- V. Types of drives in power trains
- A. Gear drives
 - B. Fluid drives
 - C. Friction drives
 - D. Belt drives
 - E. Chain drives
- VI. Types of gears (Transparency 2)
- A. Straight spur gears--These gears have straight teeth
(NOTE: These gears are noisier and used mainly for slow speed.)
 - B. Helical spur gear--The teeth are cut at an angle
(NOTE: Helical spur gears are quieter in operation and have greater strength and durability than straight spur gears because the contacting teeth are longer.)

INFORMATION SHEET

- C. Herringbone gears--Are really double helical gears with teeth angles reversed on opposite sides
- D. Planetary gears--The outer ring gear has internal teeth which mate with teeth on smaller planet gears; these gears mate with a center or sun gear
- E. Worm gears--The worm gear is actually a screw; the mating gear has teeth which are curved at the tips to permit a greater contact area; it is capable of high speed reduction
- F. Rack and pinion--Converts straight motion into rotary motion and vice versa
- G. Plain bevel gears--These gears permit the power flow to turn a corner; the gear teeth are cut straight on a line with the shaft
- H. Spiral bevel gears--These gears permit the power flow to turn a corner; the teeth are cut at an angle and used where higher speed and strength are required
- I. Hypoid gears--Resemble the spiral bevel gears but the driving gear is located below the center of the driven gear

VII. Formula for calculating gear ratios

- A. Count number of teeth on driving gear and teeth on driven gear
- B. Divide the number of teeth of the driven gear by the number of teeth of the driving gear

Example: If a driving gear has 20 teeth and driven gear has 60 teeth, the gear ratio is $60 \div 20 = 3$, or driving gear turns 3 times to one turn of driven gear.

VIII. How to determine gear rotation (Transparency 3)

- A. Gears are used to change the direction of power transmitted
- B. Gear rotation is determined by a drive gear turning in one direction (clockwise) which turns a driven gear in the opposite direction (counterclockwise)

(NOTE: Some planetary gears can be an exception to this rule.)

IX. Formula for calculating gear speed (Transparency 4)

- A. A small gear will drive a large gear more slowly but with greater torque
- B. A large gear will drive a small gear faster but with less torque

INFORMATION SHEET

- C. Formula to find gear speed: R.P.M. X No. of Teeth of drive gear =
R.P.M. X No. of Teeth of driven gear

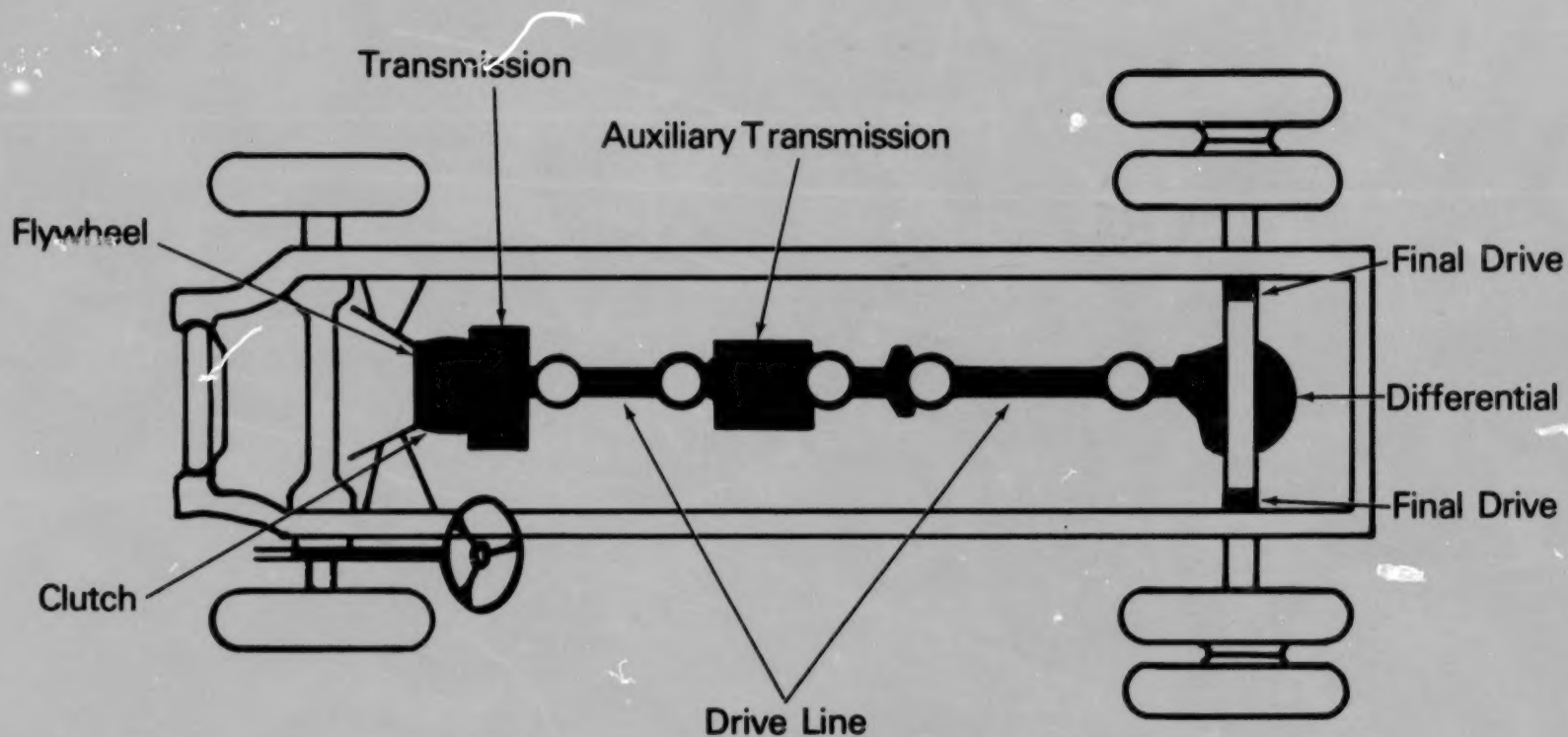
Example: If a gear with 20 teeth revolves at 500 R.P.M. and drives a gear with 40 teeth, how many R.P.M. would the gear with 40 teeth make?

$$500 \times 20 = X \times 40$$

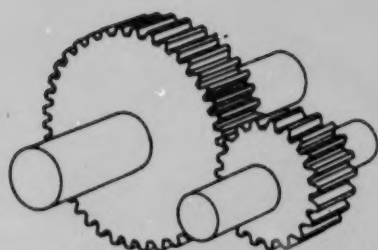
$$10,000 = 40 X$$

$$250 = X$$

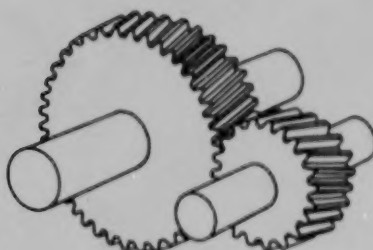
Basic Power Train Components



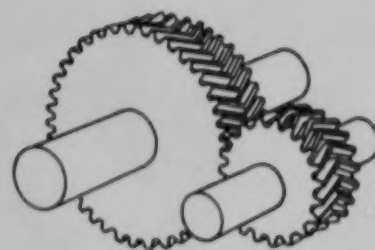
Types of Gears



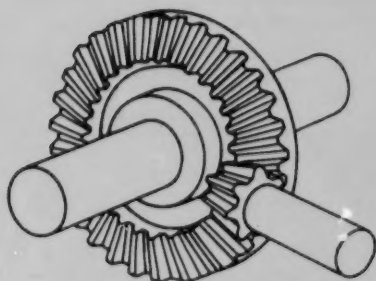
Straight Spur



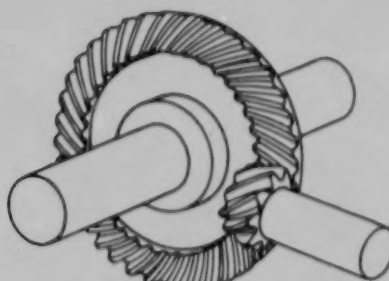
Helical Spur



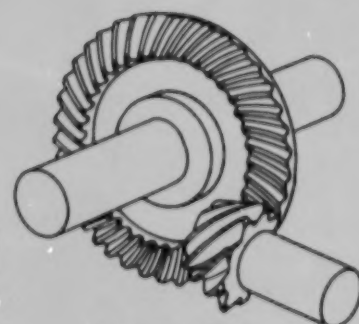
Herringbone



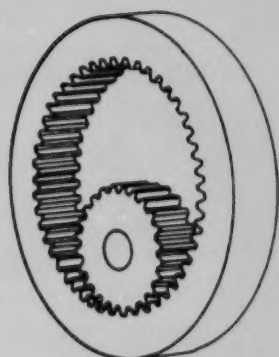
Plain Bevel



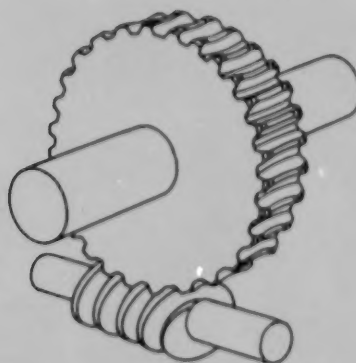
Spiral Bevel



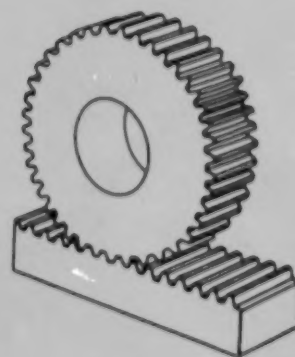
Hypoid



Planetary



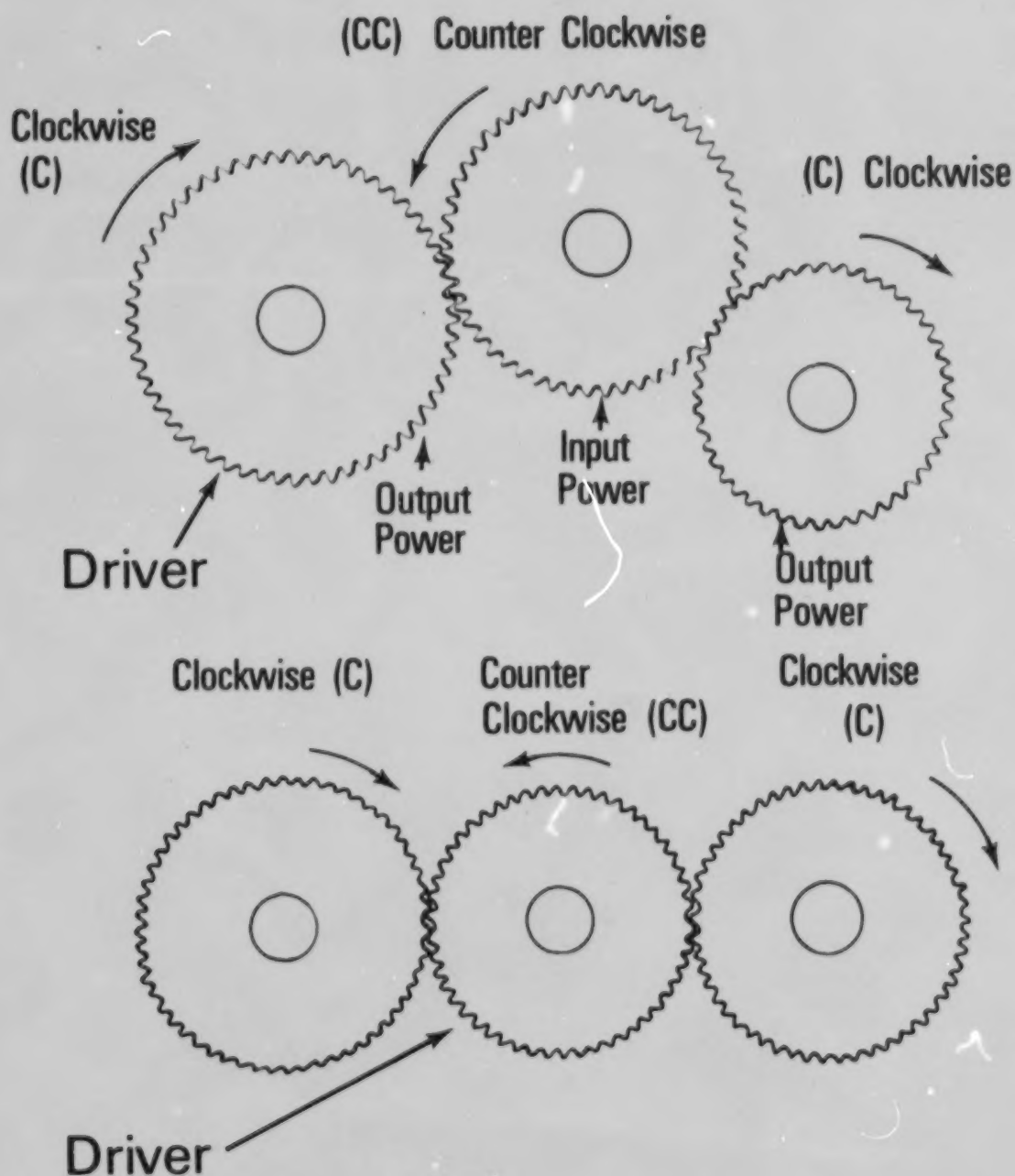
Worm



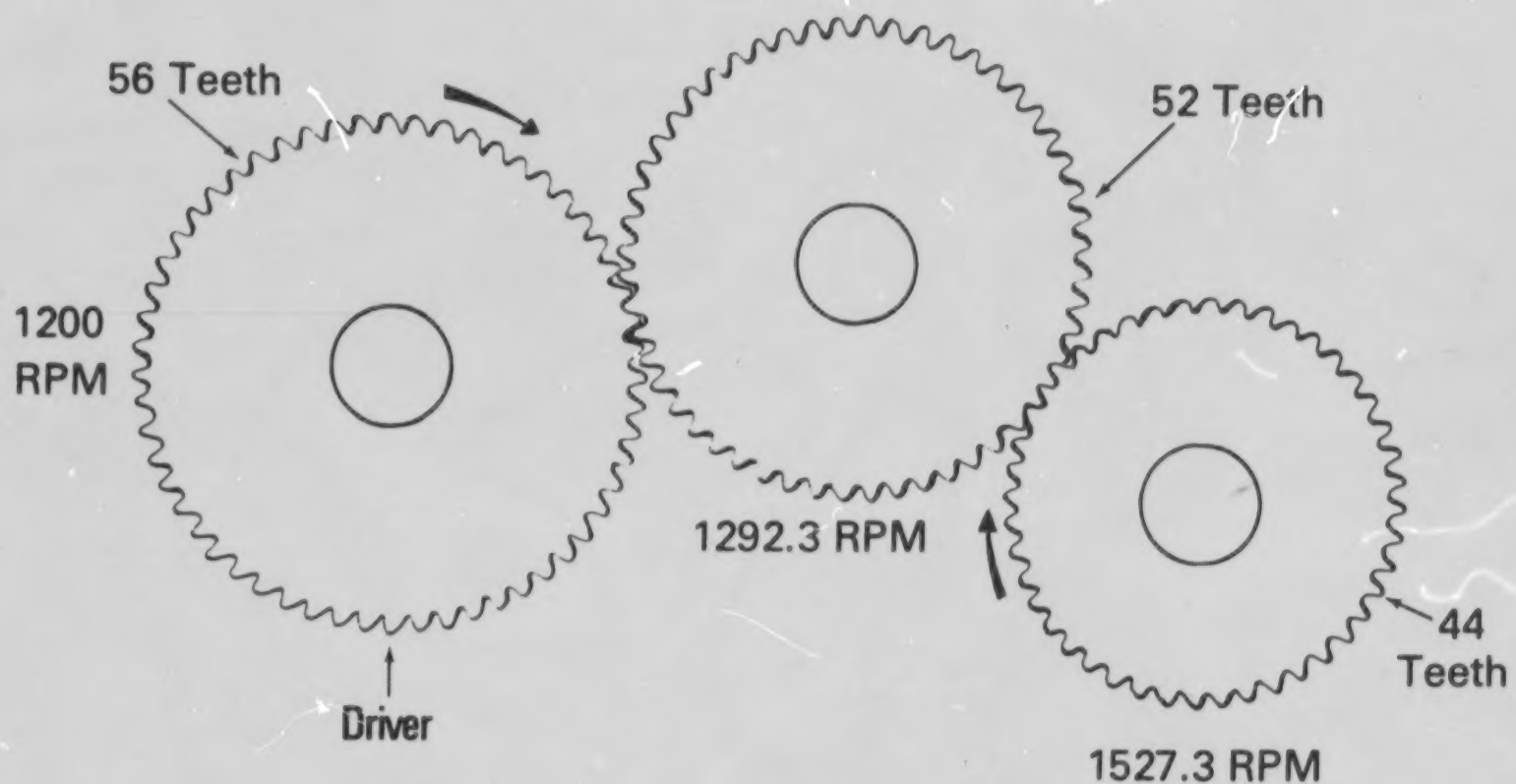
Rack and Pinion

Courtesy DEERE & CO., MOLINE, IL

How Gears Change Direction of Rotation



How Gears are Used to Change Speed



INTRODUCTION TO POWER TRAINS
UNIT I

ASSIGNMENT SHEET #1--CALCULATE GEAR RATIO

Directions: Using the information sheet, calculate the gear ratio of the gears below and write correct answers in blanks provided.

A. Calculate gear ratio from information given

1. Driven gear has 9 teeth
Driving gear has 36 teeth

What is the gear ratio? _____

2. Driven gear has 36 teeth
Driving gear has 48 teeth

What is the gear ratio? _____

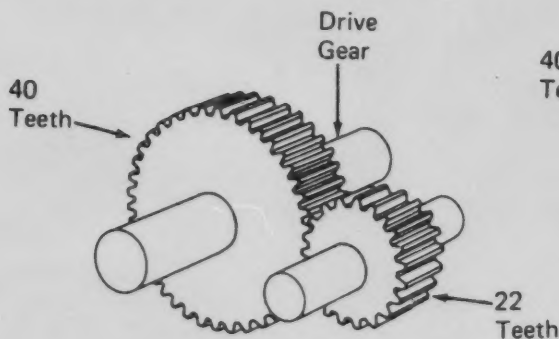
3. Driven gear has 36 teeth
Driving gear has 12 teeth

What is the gear ratio? _____

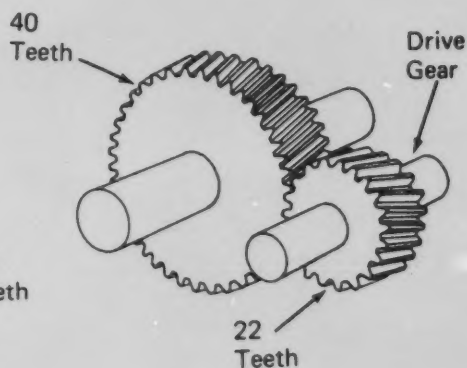
4. Driven gear has 50 teeth
Driving gear has 10 teeth

What is the gear ratio? _____

B. Calculate gear ratio from illustrations

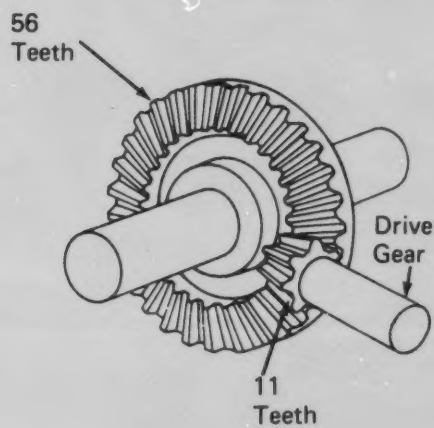
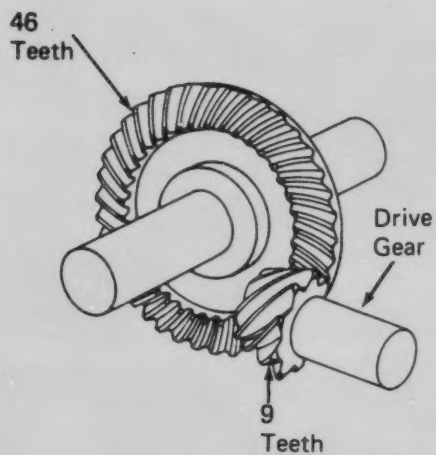
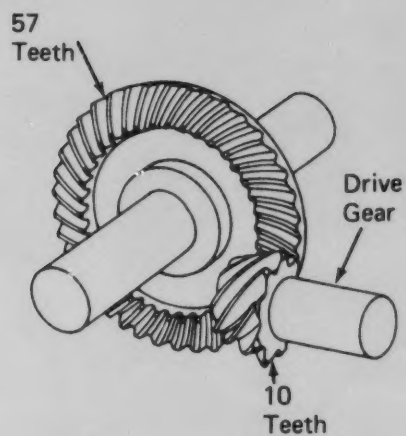
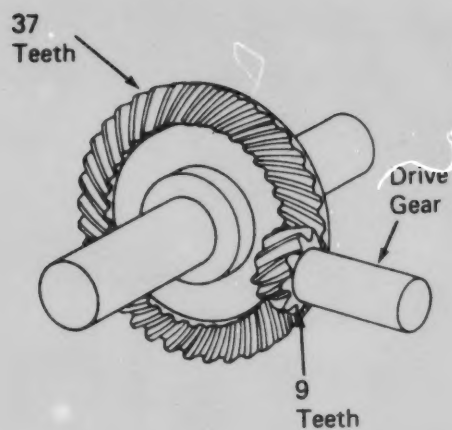


1. _____



2. _____

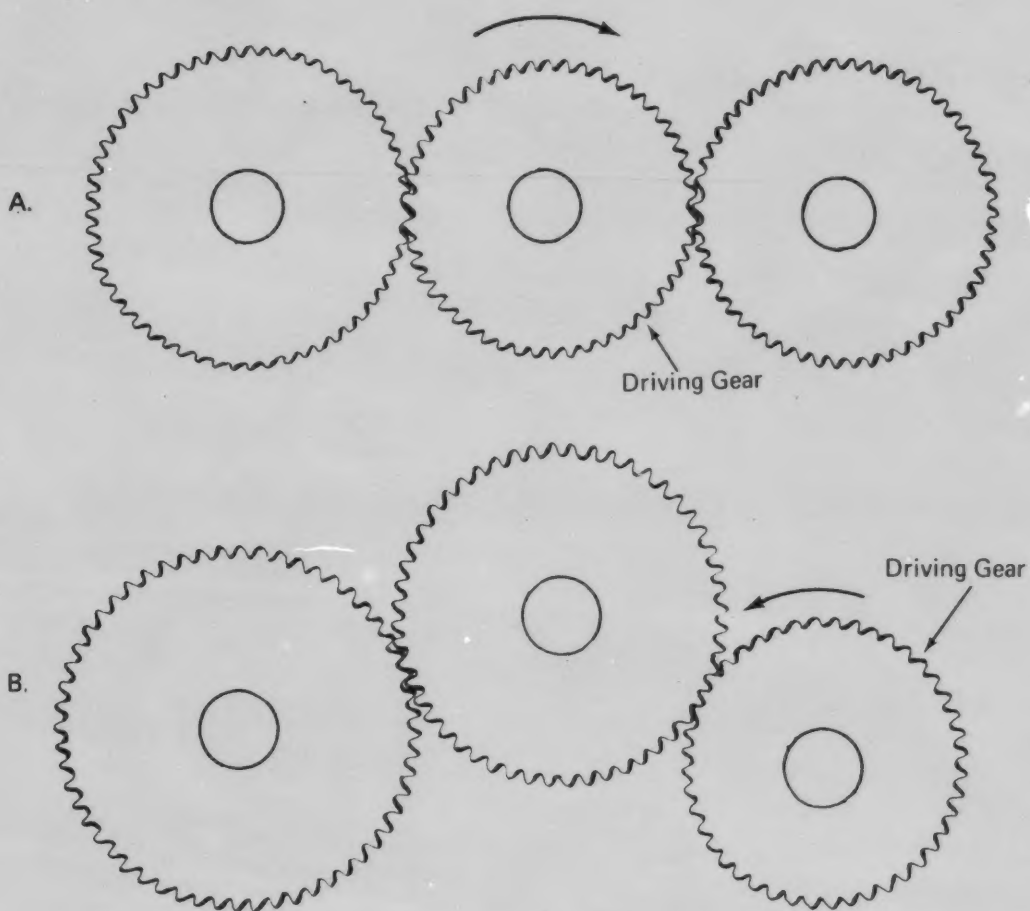
ASSIGNMENT SHEET #1



INTRODUCTION TO POWER TRAINS
UNIT I

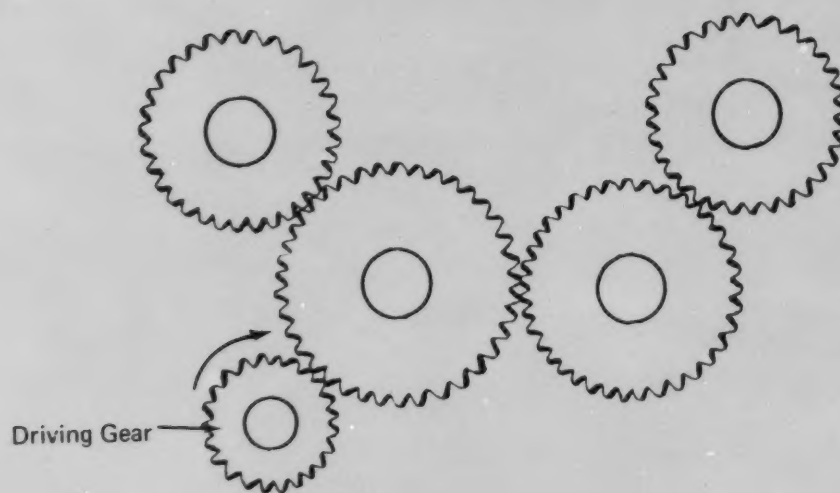
ASSIGNMENT SHEET #2--CALCULATE GEAR ROTATION

Directions: Calculate gear rotation by indicating with an arrow the direction the driven gears are turning.



ASSIGNMENT SHEET #2

C.

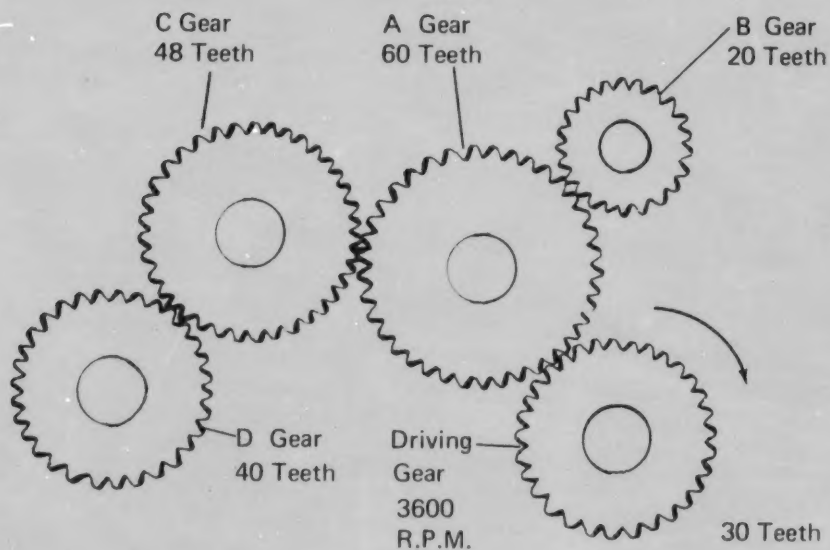


INTRODUCTION TO POWER TRAINS UNIT I

ASSIGNMENT SHEET #3--CALCULATE GEAR SPEED

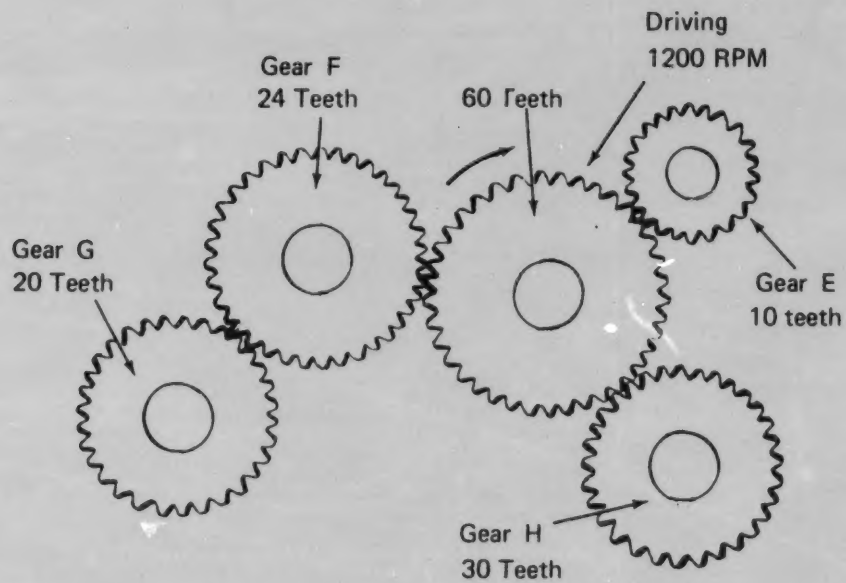
Directions: Calculate the direction of rotation, the gear ratio, and the RPM of each driven gear and write the correct answers in the blanks provided.

A.	Rotation	Ratio	R.P.M.
1. Gear A	_____	_____	_____
2. Gear B	_____	_____	_____
3. Gear C	_____	_____	_____
4. Gear D	_____	_____	_____



ASSIGNMENT SHEET #3

B.		Rotation	Ratio	R.P.M.
1.	Gear E	_____	_____	_____
2.	Gear F	_____	_____	_____
3.	Gear G	_____	_____	_____
4.	Gear H	_____	_____	_____



INTRODUCTION TO POWER TRAINS
UNIT I

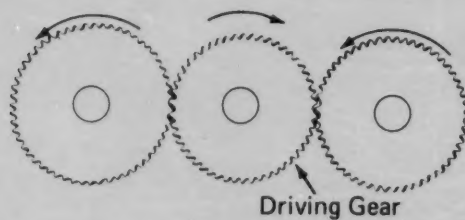
ANSWERS TO ASSIGNMENT SHEETS

Assignment Sheet #1

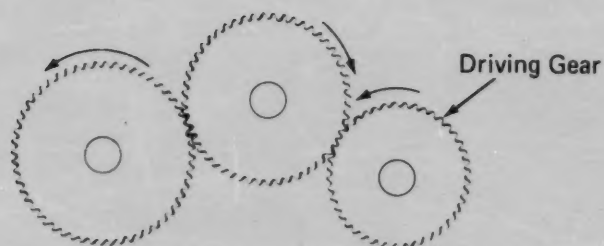
- A. 1. .25:1
2. .75:1
3. 3:1
4. 5:1
- B. 1. .55:1
2. 1.82:1
3. 4:11:1
4. 5.70:1
5. 5.11:1
6. 5.09:1

Assignment Sheet #2

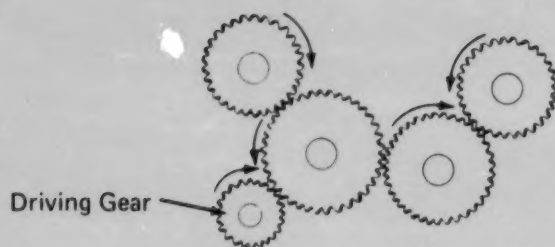
A.



B.



C.



Assignment Sheet #3

A.		Rotation	Ratio	R.P.M.
1.	Gear A	CC	2:1	1800
2.	Gear B	C	.33:1	5400
3.	Gear C	C	.80:1	2250
4.	Gear D	CC	.83:1	2700

B.		Rotation	Ratio	R.P.M.
1.	Gear E	CC	.16:1	7200
2.	Gear F	CC	.40:1	3000
3.	Gear G	C	.83:1	3600
4.	Gear H	CC	.50:1	2400

INTRODUCTION TO POWER TRAINS UNIT I

NAME _____

TEST _____

1. Match the terms on the right with their correct definitions.

- | | |
|---|----------------------------|
| _____ a. Revolving components involved in the transmission of power from the engine to the drive wheels | 1. Torque |
| _____ b. The number of revolutions the driving gear must make to turn the driven gear one revolution | 2. Preload |
| _____ c. A turning or twisting force | 3. Gear ratio |
| _____ d. The clearance or play between two gears in mesh | 4. Constant mesh |
| _____ e. End-to-end movement in a gear shaft due to bearing clearances | 5. Power train |
| _____ f. Adjustment of antifriction bearings so that they are under mild pressure; tested by the amount of torque in inch pounds required to turn the shaft | 6. Backlash |
| _____ g. A combination of gears used to reduce the input speed to a lower output speed | 7. Splines |
| _____ h. Gears that are always in mesh with each other | 8. Endplay |
| _____ i. Multiple keys in the general form of internal and external gear teeth, used to prevent rotation of a shaft | 9. Gear reduction |
| _____ j. A unit mounted behind the main transmission to provide supplemental gearing | 10. Auxiliary transmission |

2. Match the basic components of a power train on the right with their functions.

- | | |
|--|-----------------|
| _____ a. A rotating metal disc on the rear end of a crankshaft designed to even out power surges during power strokes and deliver energy back during other strokes | 1. Transmission |
| _____ b. A device that connects or disconnects a power source from the part it operates to provide a smooth transmission of torque to working parts in movement | 2. Final drive |

- _____ c. A device in a power train that increases torque by changing gear ratios, permitting a vehicle to move at varying speeds in both forward and reverse
- _____ d. Components that transmit torque from the transmission to the differential; made up of one or more drive shafts with universal and slip joints
- _____ e. A mechanism that drives both rear wheels at the same time but permits the wheels to turn at different speeds so the vehicle can turn corners
- _____ f. The last phase of a power train; it gives final reduction in speed and increase in torque to the drive wheels

- 3. Flywheel
- 4. Differential
- 5. Clutch
- 6. Drive line

3. Arrange in order the sequence for the transmission of power through the power train by placing the correct sequence number in the appropriate blank.

- _____ a. Clutch is bolted to flywheel to send power to transmission
- _____ b. Drive line sends the power to the differential by the pinion and ring gear
- _____ c. Power is transmitted from clutch through transmission at various speeds
- _____ d. Power from engine is transmitted to flywheel
- _____ e. The power comes out of transmission to drive line
- _____ f. The differential puts the power out to the final drive

4. Select working applications of power trains by placing an "X" in appropriate blanks.

- _____ a. Power generators
- _____ b. Airplanes
- _____ c. Trucks
- _____ d. Industrial and off-road equipment
- _____ e. Marine

5. Select types of drives in power trains by placing an "X" in the appropriate blanks.

- _____ a. Pneumatic drives
- _____ b. Gear drives
- _____ c. Fluid drives

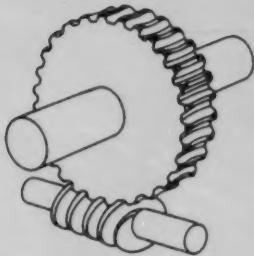
____ d. Friction drives

____ e. Chain drives

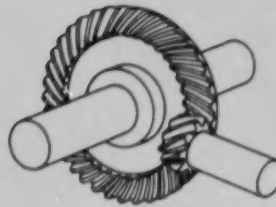
____ f. Air drives

____ g. Belt drives

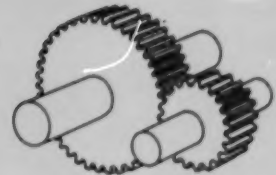
6. Identify types of gears by writing the names in the blanks provided.



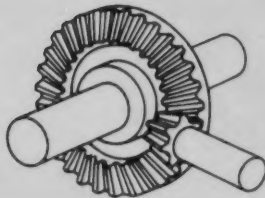
a.



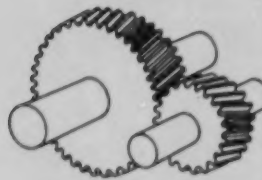
b.



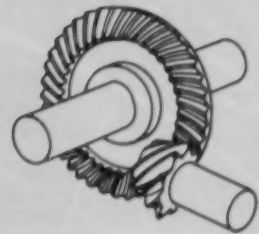
c.



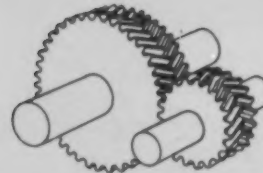
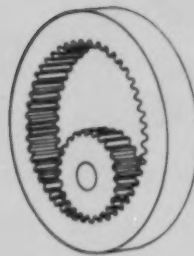
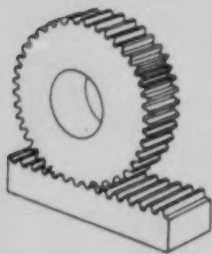
d.



e.



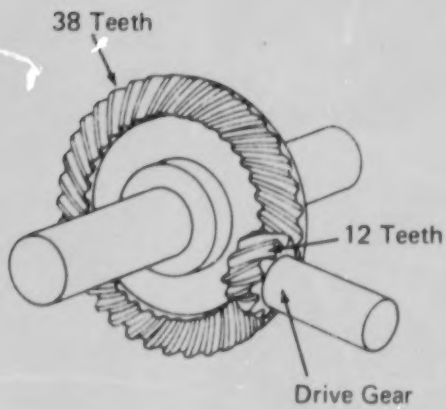
f.



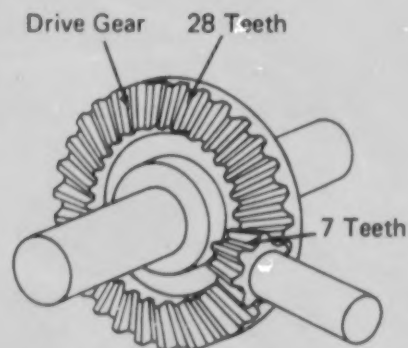
g. _____ h. _____ i. _____

7. Solve the following problems by using the formula for calculating gear ratios.

- a. Driven gear has 64 teeth
Driving gear has 36 teeth _____



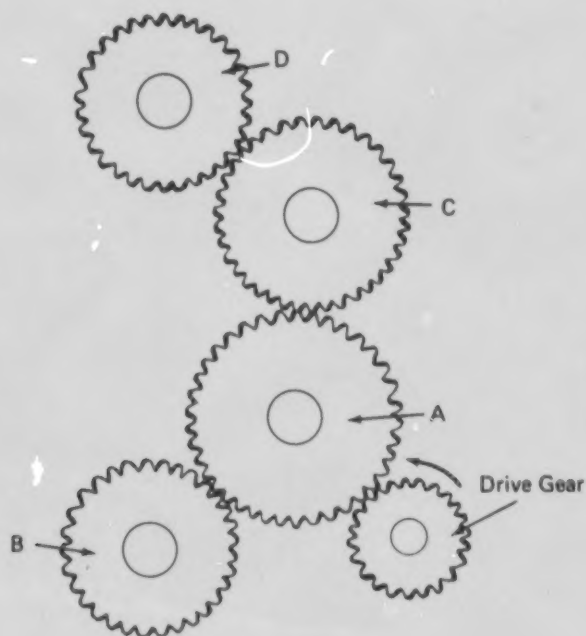
b. _____



c. _____

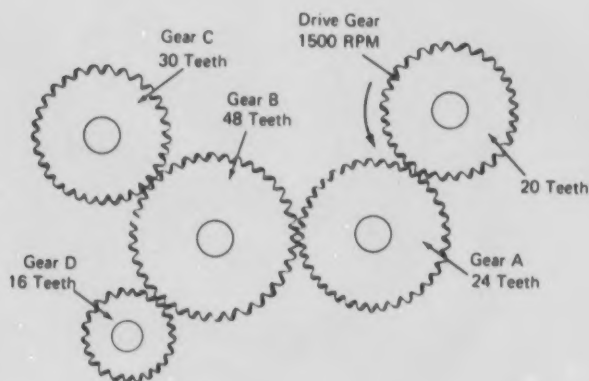
8. Solve the following problems concerning how to determine gear rotation by writing "C" for clockwise or "CC" for counterclockwise in the blanks provided.

- ____ a. Gear A
____ b. Gear B
____ c. Gear C
____ d. Gear D



9. Solve the following problems by using the formula for calculating gear speed.

	Rotation	Ratio	RPM
Gear A	<u>C</u>	<u>1.20:1</u>	<u> </u>
Gear B	<u>CC</u>	<u>2:1</u>	<u> </u>
Gear C	<u>C</u>	<u>.63:1</u>	<u> </u>
Gear D	<u>C</u>	<u>.33:1</u>	<u> </u>



10. Demonstrate the ability to:

- Calculate gear ratio
- Calculate gear rotation
- Calculate gear speed

(NOTE: If these activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

INTRODUCTION TO POWER TRAINS UNIT I

ANSWERS TO TEST

1. a. 5 f. 2
 b. 3 g. 9
 c. 1 h. 4
 d. 6 i. 7
 e. 8 j. 10
2. a. 3
 b. 5
 c. 1
 d. 6
 e. 4
 f. 2
3. a. 2 d. 1
 b. 5 e. 4
 c. 3 f. 6
4. a, c, d, e
5. b, c, d, e, g
6. a. Worm f. Hypoid
 b. Spiral bevel g. Rack and pinion
 c. Straight spur h. Planetary
 d. Plain bevel i. Herringbone
 e. Helical spur
7. a. 1.77:1
 b. 3.16:1
 c. .25:1
8. Gear A -- C
 Gear B -- CC
 Gear C -- CC
 Gear D -- C
9.

	Rotation	Ratio	RPM
Gear A	C	1.20:1	1250
Gear B	CC	2:1	625
Gear C	C	.63:1	1000
Gear D	C	.33:1	1875

10. Evaluated to the satisfaction of the instructor

CLUTCHES AND FLYWHEELS UNIT II

UNIT OBJECTIVE

After completion of this unit, the student should be able to identify parts of flywheel and clutch assemblies. The student should also be able to adjust a pressure plate, check flywheel runout, and remove, inspect, and correctly install a clutch assembly. This knowledge will be evidenced by correctly performing the procedures outlined in the job sheets and by scoring 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms related to clutches and flywheels with their correct definitions.
2. Identify the components of a basic clutch assembly.
3. Identify parts of a flywheel.
4. Select from a list the functions of a flywheel.
5. Identify parts of a dry-type disc clutch.
6. Match types of clutches with their descriptions.
7. Identify types of pressure plates.
8. Distinguish between a disengaged and an engaged clutch.
9. Match types of clutch linkage mechanisms with their functions.
10. Select from a list conditions to look for during clutch inspection.
11. Select from a list the symptoms that occur when a clutch housing bore has excessive runout.
12. Match clutch malfunctions with probable causes.
13. List purposes of a dual disc clutch.
14. Demonstrate the ability to:
 - a. Adjust clutch linkage free travel.
 - b. Adjust free travel on a pull type clutch.
 - c. Remove a clutch assembly.

- d. Inspect a clutch disc.
- e. Check a clutch housing alignment.
- f. Inspect a pressure plate and cover.
- g. Inspect a pilot bearing and pilot bushing.
- h. Reinstall a clutch assembly.
- i. Remove, inspect, repair, and reinstall a 15 1/2-inch dual disc clutch.
- j. Disassemble, inspect, and reassemble a hydraulic (wet-type) clutch.
- k. Check flywheel runout.
- l. Remove and replace a flywheel ring gear.

CLUTCHES AND FLYWHEELS UNIT II

SUGGESTED ACTIVITIES

- I. Provide student with objective sheet.
- II. Provide student with information and job sheets.
- III. Make transparencies.
- IV. Discuss unit and specific objectives.
- V. Discuss information sheet.
- VI. Demonstrate and discuss the procedures outlined in the job sheets.
- VII. Take students on field trip to a shop that rebuilds clutch discs or pressure plates.
- VIII. Supply films on clutch components and adjustments mechanism.
- IX. Take students on field trip to a diesel shop to watch the procedure for removing and replacing a clutch assembly.
- X. Have a speaker come in from different power train manufacturers to discuss the operation of different clutch assemblies.
- XI. Demonstrate different instruments used to measure the components of a flywheel, clutch disc, and pressure plate.
- XII. Give test.

INSTRUCTIONAL MATERIALS

- I. Included in this unit:
 - A. Objective sheet
 - B. Information sheet
 - C. Transparency masters
 1. TM 1--Components of a Basic Clutch Assembly
 2. TM 2--Parts of a Flywheel
 3. TM 3--Parts of a Flexible Disc
 4. TM 4--Parts of a Rigid Disc
 5. TM 5--Disc-Type and Band-Type Clutches
 6. TM 6--Types of Overrunning Clutches
 7. TM 7--Types of Magnetic Clutches

8. TM 8--Other Types of Clutches
9. TM 9--Types of Pressure Plates
10. TM 10--Pull Type Pressure Plate
11. TM 11--Clutch Operation
12. TM 12--Basic Mechanical Linkage Mechanism
13. TM 13--Basic Hydraulic System
14. TM 14--Basic Air Operated Mechanism
15. TM 15--Clutch Inspection
16. TM 16--Clutch Inspection (Continued)
17. TM 17--Heavy Duty Dual Disc Clutch Components

D. Job sheets

1. Job Sheet #1--Adjust Clutch Linkage Free Travel
2. Job Sheet #2--Adjust Free Travel on a Pull Type Clutch
3. Job Sheet #3--Remove a Clutch Assembly
4. Job Sheet #4--Inspect a Clutch Disc
5. Job Sheet #5--Check a Clutch Housing Alignment
6. Job Sheet #6--Inspect a Pressure Plate and Cover
7. Job Sheet #7--Inspect a Pilot Bearing and Pilot Bushing
8. Job Sheet #8--Reinstall a Clutch Assembly
9. Job Sheet #9--Remove, Inspect, Repair, and Reinstall a 15 1/2-Inch Dual Disc Clutch
10. Job Sheet #10--Disassemble, Inspect, and Reassemble a hydraulic (Wet-Type) Clutch
11. Job Sheet #11--Check Flywheel Runout
12. Job Sheet #12--Remove and Replace a Flywheel Ring Gear

E. Test

F. Answers to test

II. References:

- A. Stockel, Martin W. *Auto Service and Repair*. South Holland, IL: The Goodheart-Willcox Co., Inc., 1969.
- B. Forier, Louis C. *Motor Trucks and Diesel Repair Manual*. 33rd Edition. New York, NY 10019: Motor, 1980.
- C. *Service Manual: Detroit Diesel Engines In-Line 71*. Detroit, MI 48228: Detroit Diesel Allison Division of General Motors Corporation, 1979.
- D. *Fundamentals of Service: Power Trains*. Moline, IL 61625: John Deere Service Publication, Dept. F, 1972.
- E. Notgrass, Troy. *The Automotive Power Train Mechanic*. Austin, TX Instructional Materials Service Division of Extension, The University of Texas at Austin, 1973.
- F. *1968 Ford Truck Shop Manual*. Dearborn, MI: Ford Service Publications, 1968.
- G. *Lipe Clutches Service Manual*. Syracuse, NY: Lipe-Rollway Corporation, 1963.
- H. *International Motor Truck Service Manual Transmission, Section T*. Chicago, IL 60611: International Harvester Company, 1968.
- I. Schulz, Erich J. *Diesel Equipment II*. Dallas, TX: Gregg Division, McGraw-Hill, Inc., 1982.

CLUTCHES AND FLYWHEELS UNIT II

INFORMATION SHEET

I. Terms and definitions

- A. Flywheel--Heavy metal disc which has a friction surface for clutch plate, supports all of the clutch components, and provides gear teeth on outer rim for starting-motor operation
- B. Pilot bearing--Bearing located in the flywheel flange of the crankshaft which allows for correct support and alignment of transmission input shaft
- C. Friction--Resistance to movement between any two objects placed in contact with each other
- D. Clutch disc--Provides a friction surface between pressure plate and flywheel, and is splined to fit the transmission input shaft
- E. Pressure plate--Mounted to the flywheel and supplies the force that holds the clutch plate against the flywheel, causing the flywheel, clutch disc, and pressure plate to rotate as one
- F. Clutch cover--Houses the release levers, springs, and pressure plate
- G. Clutch release bearing--Also known as throw-out bearing; used to activate the release levers or diaphragm
- H. Release fork--Y-shaped lever inside clutch housing used to engage and disengage clutch
- I. Free travel--The distance a clutch pedal must travel from its normal position to the point at which the throw-out bearing engages the release levers
- J. Clutch disc spin time--Time it takes for the clutch disc to stop spinning after clutch release
- K. Release fork ball--Acts as a pivot for release fork
- L. Slave cylinder--Used on hydraulic clutch system to transmit pressure to throw-out lever
- M. Master cylinder--A hydraulic device that forces hydraulic pressure to a slave cylinder to disengage the clutch; it also activates hydraulic brakes
- N. Clutch housing--Covers flywheel clutch assembly and provides surface to bolt transmission to engine
- O. Clutch brake--A mechanism on the input shaft which helps slow the rotation of the input shaft and the clutch disc to make shifting easier

INFORMATION SHEET

II. Components of a basic clutch assembly (Transparency 1)

- A. Clutch pilot bearing
- B. Flywheel ring gear
- C. Flywheel
- D. Clutch disc
- E. Pressure plate
- F. Clutch release bearing
- G. Clutch release fork
- H. Release fork ball

III. Parts of a flywheel (Transparency 2)

- A. Clutch disc contact surface
- B. Flywheel
- C. Ring gear
- D. Clutch pilot bearing bore
- E. Pressure plate mounting surface

IV. Functions of a flywheel

- A. Stores up energy during power stroke and delivers energy back during the other strokes
- B. Ring gear is mounted around the circumference of flywheel to provide a means for starting
- C. A flat surface is machined smooth to provide a friction surface for the clutch

V. Parts of a dry-type disc clutch (Transparencies 3 and 4)

- A. Facings
- B. Drive washer
- C. Torsional coil springs
- D. Cushion springs
- E. Stop pin

INFORMATION SHEET

- F. Hub flange
- G. Friction ring

VI. Types of clutches and their descriptions (Transparencies 5, 6, 7, and 8)

- A. Disc-type--One or more plates are brought together to transmit torque

(NOTE: There are two major types of disc clutches: the dry-type disc which operates dry, cooled by air and the wet-type disc which operates in either oil bath or spray, cooled by oil.)

- B. Band-type--An outside band is tightened over a rotating part to transmit torque

- C. Overrunning-type--Engagement is allowed in one direction, but the unit freewheels in the other

(NOTE: Overrunning clutches have three basic types: roller, cam or sprag, and spring.)

- D. Magnetic-type--A magnetic field holds two parts together, allowing them to rotate as a unit

(NOTE: There are two types of magnetic clutches: direct action and indirect action.)

- E. Cone-type--Two cone-shaped parts are engaged to transmit torque

- F. Expanding-shoe-type--An inner shoe is expanded to contact an outer part to transmit torque

- G. Over center-type--A pressure plate is forced indirectly over levers and links against the clutch disc; as the clutch is engaged, the levers and links come over the center of the pivot point and lock the engagement

VII. Types of pressure plates (Transparency 9)

- A. Push type

1. Diaphragm spring
2. Coil spring
3. Centrifugal and coil spring
4. Over center clutch

- B. Pull type--A coil spring type with an adjusting sleeve connecting the release levers to the release bearing (Transparency 10)

INFORMATION SHEET

VIII. Operating principles of the clutch (Transparency 11)

- A. Disengaged--Throw-out bearing presses the free end of release levers inward, while other end of release levers moves the pressure plate from the clutch disc
- B. Engaged--The throw-out bearing is brought back away from the free end of release levers (free travel); the springs force the pressure plate against clutch disc and flywheel

IX. Types of clutch linkage mechanisms and their functions

- A. Mechanical linkage--This method uses a series of levers and rods connecting the foot pedal to the throw-out fork (Transparency 12)

(NOTE: Some may be actuated by cable.)

- B. Hydraulic operated--A master cylinder is connected to, and actuated by, the clutch pedal; the pressure created by depressing the foot pedal is transmitted to the slave cylinder through high pressure hoses; the slave cylinder is mounted near, and connected to, the throw-out lever or fork (Transparency 13)
- C. Air operated--This mechanism uses compressed air and hydraulic assembly supply power for clutch operation on vehicles equipped with a hydraulic clutch cylinder (Transparency 14)
- D. Electrically operated (Transparency 7)
 - 1. Direct-action clutch consists of a field coil assembly, rotor unit, face plate, condenser, and an operating switch
 - 2. Indirect-action clutch consists of a driving member containing a coil, an inner driven member, and a mixture of magnetizable metal and dry lubricant

X. Conditions to look for during clutch inspection (Transparencies 15 and 16)

- A. Finger and/or lever wear
- B. Excessive finger wear
- C. Slight chatter marks
- D. Excessive heat discoloration
- E. Excessive warpage
- F. Heat cracks
- G. Wear pattern from warped pressure plate or flywheel
- H. Worn clutch disc
- I. Loose or worn clutch disc hub

INFORMATION SHEET

- J. Worn clutch shaft spline
- K. Worn pilot bearing
- L. Weak pressure plate spring tension
- M. Release fork pivot and finger wear
- N. Notched or rough release bearing support
- O. Clutch or flywheel housing alignment
- XI. Symptoms that may occur when a clutch housing bore has excessive runout
 - A. Excessive transmission gear wear or noise
 - B. Transmission jumping out of gear
 - C. Drive line vibration
 - D. Clutch pedal vibration
 - E. Grabby pedal feel
 - F. Pilot bearing noise
 - G. Excessive clutch spin time
- XII. Clutch malfunctions and probable causes
 - A. Slip
 - 1. Pressure plate spring tension weak
 - 2. Excessively worn clutch disc
 - 3. Oil contamination
 - 4. Improperly adjusted clutch linkage
 - B. Drag
 - 1. Pressure plate not releasing due to improper linkage adjustment
 - 2. Broken pivots in pressure plate
 - 3. Defective pilot bearing
 - 4. Clutch or housing alignment
 - C. Grab
 - 1. Oil contamination on clutch assembly
 - 2. Broken motor mounts

INFORMATION SHEET

3. Glazed clutch surface from being overheated

4. Weak pressure plate spring

D. Chatter

1. Oil contamination

2. Clutch disc glazed from overheating

3. Warped pressure plate or flywheel

4. Weak pressure plate spring

5. Improperly adjusted release lever

E. Freezing--Water contaminated clutch disc rusted to flywheel and pressure plate

F. Binding

1. Worn or misaligned linkage

2. Release bearing dragging on support

G. Bearing noise

1. Worn or dry pilot or release bearing when clutch is disengaged

2. Pitted clutch shaft bearing when the clutch is engaged with transmission in neutral

3. Worn pilot bearing

H. Pulsating pedal--Uneven pressure plate finger height

XIII. Purposes of a dual disc clutch (Transparency 17)

A. For equipment with heavy loads

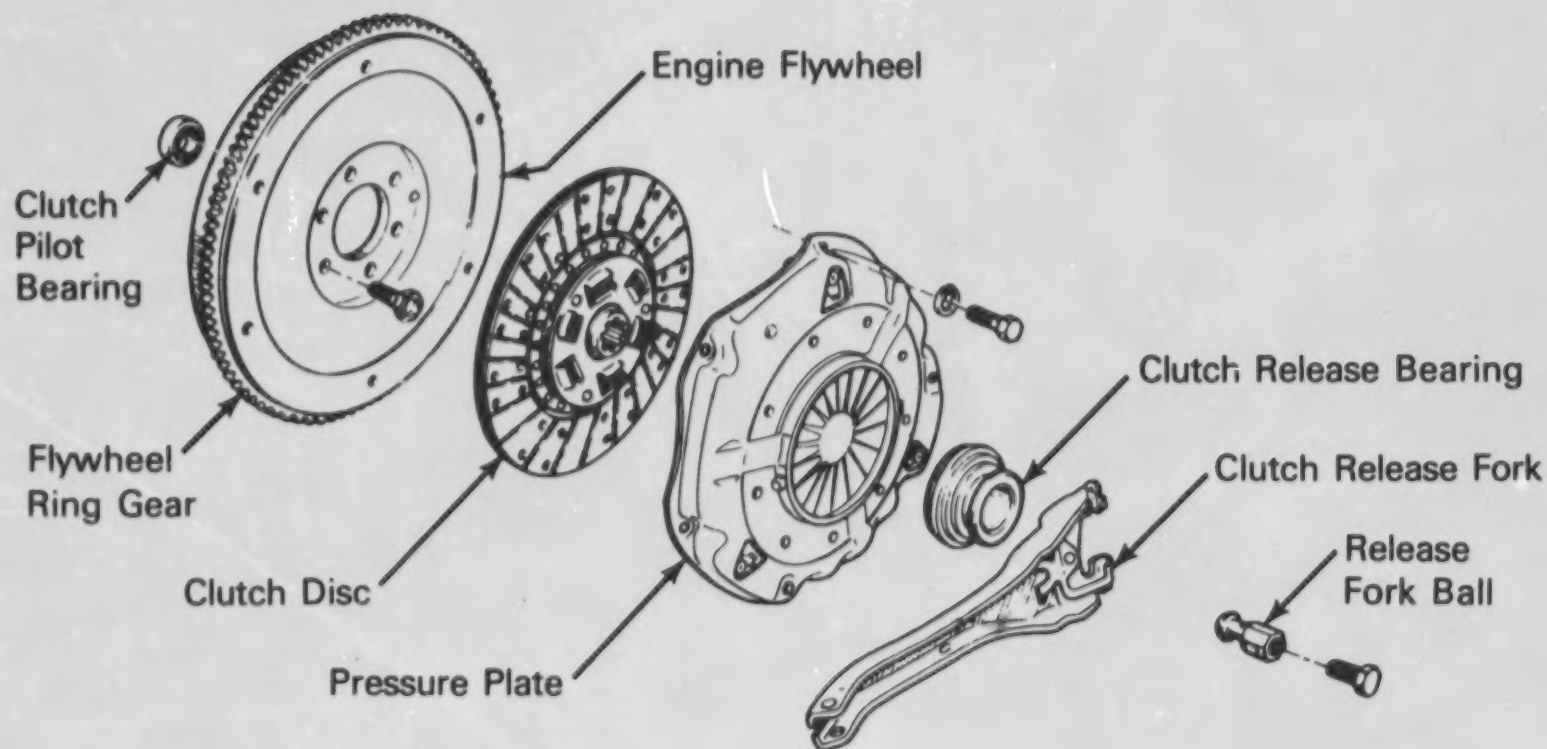
B. For engines with high torque and horsepower

C. Allows more friction surface area

D. Doesn't put an excessive load on one clutch disc

E. Allows vehicle to start moving without jerking or jumping

Components of a Basic Clutch Assembly

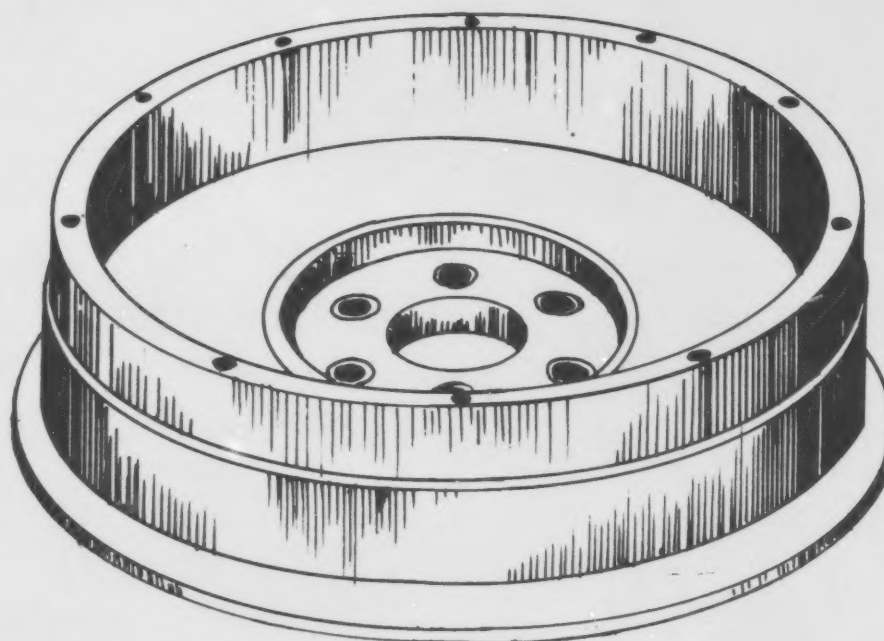
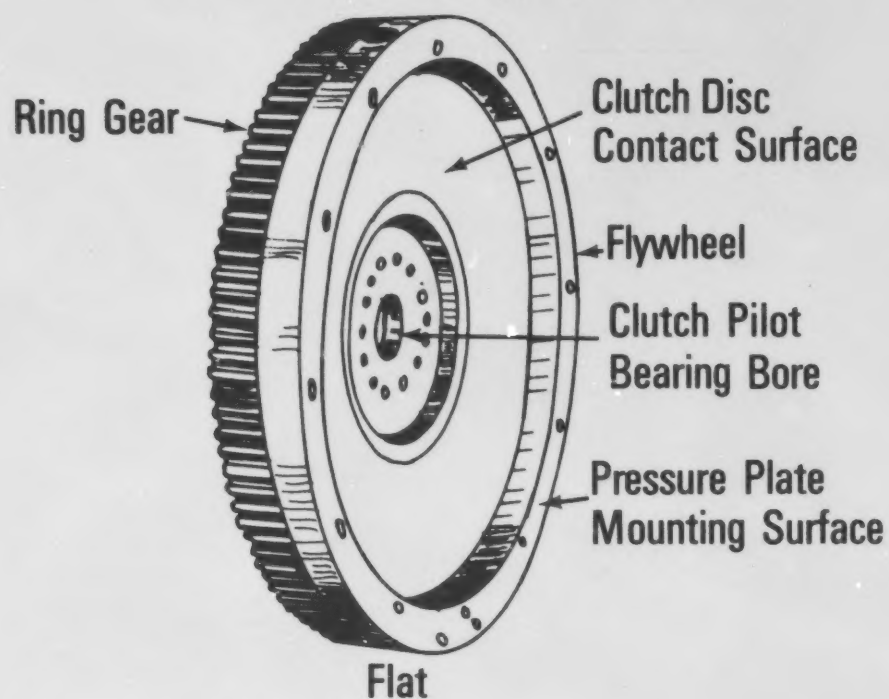


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Courtesy General Motors Corporation

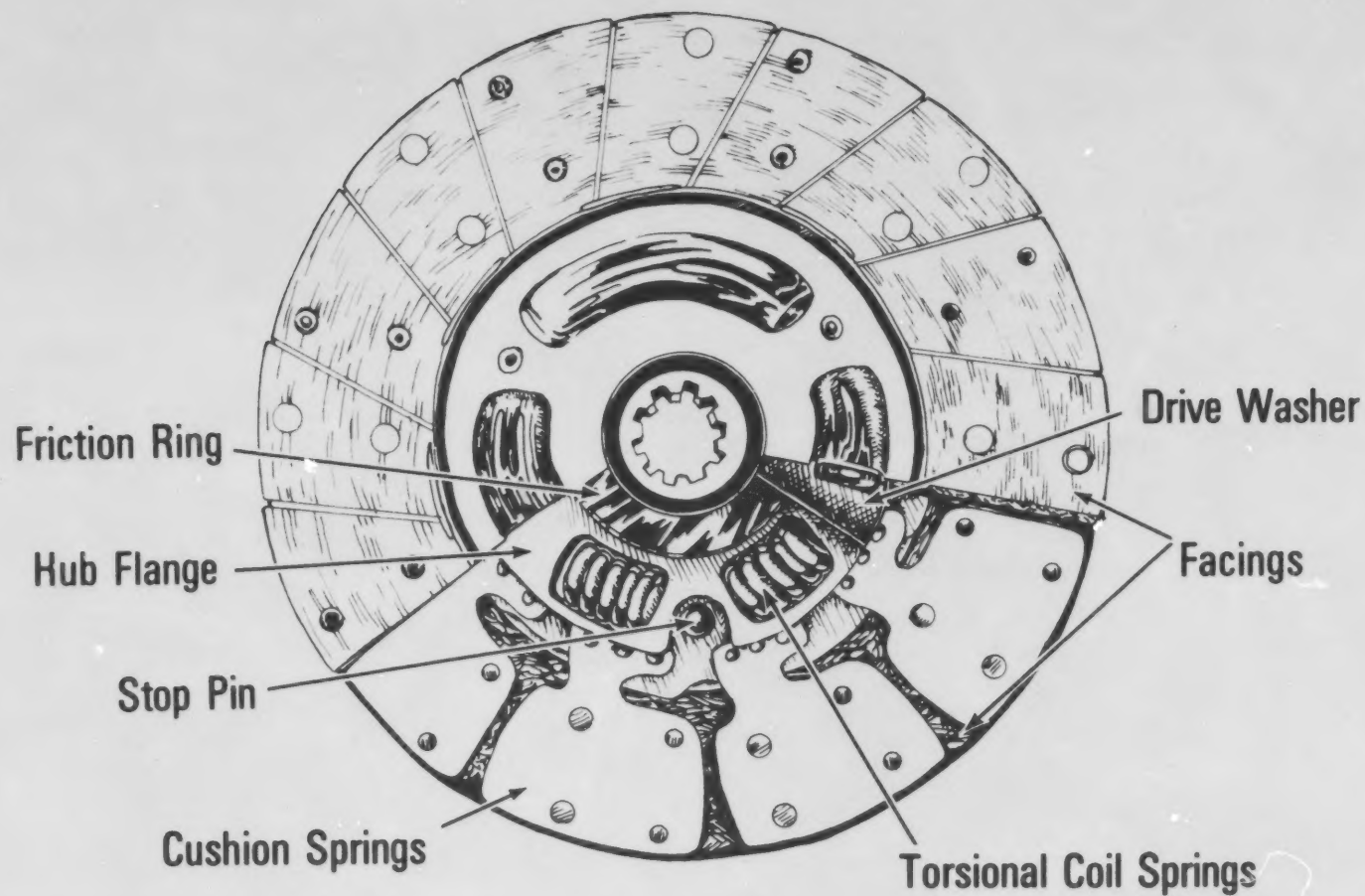
68

Parts of a Flywheel

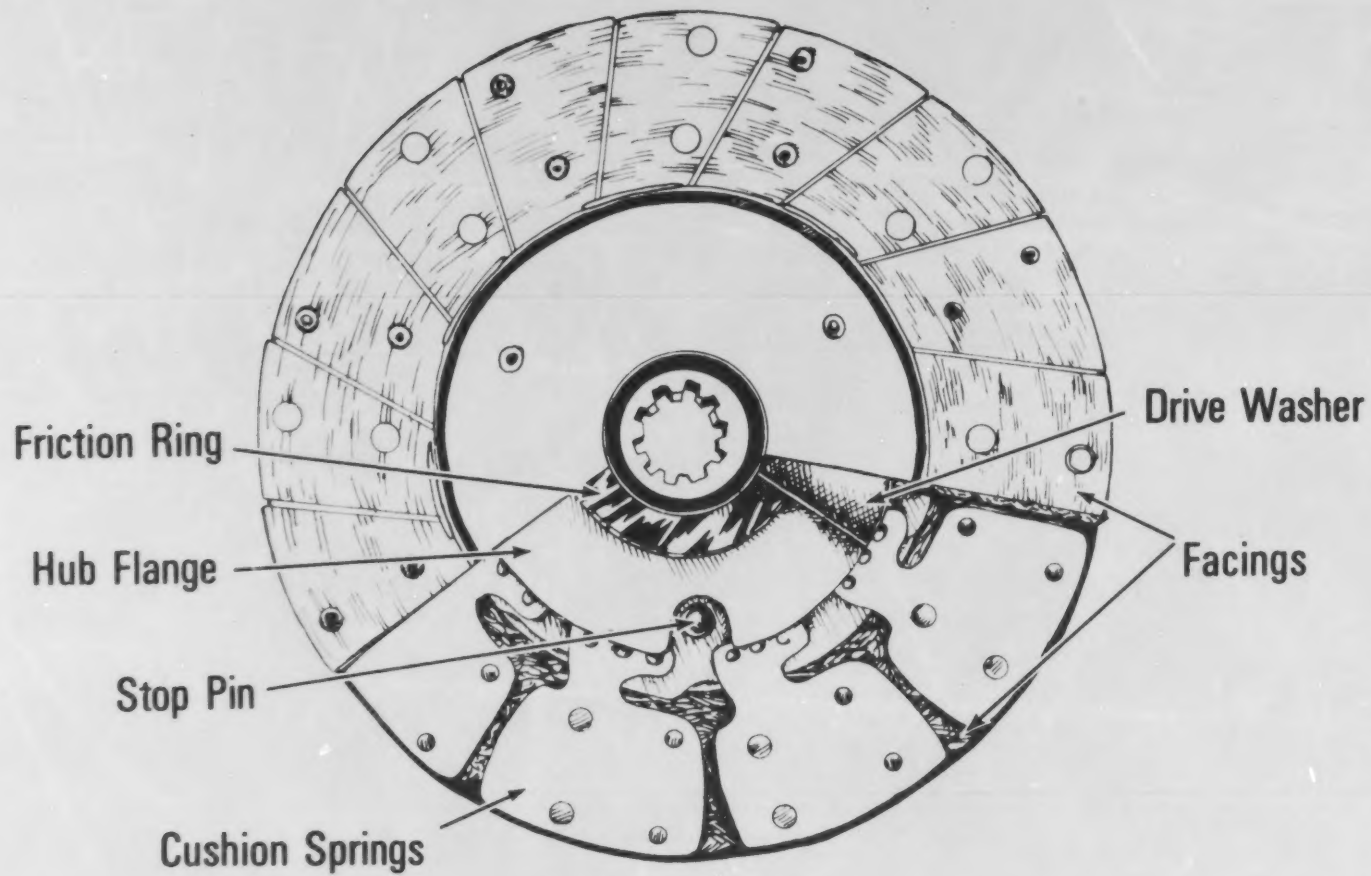


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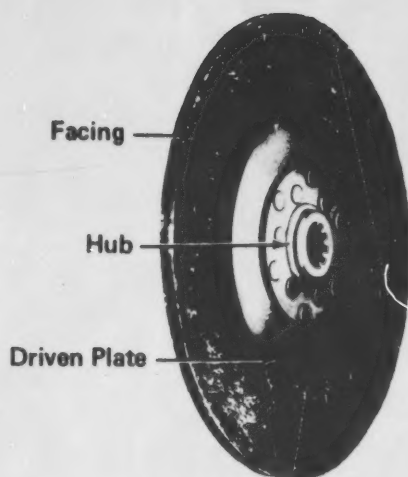
Parts Of A Flexible Disc



Parts Of A Rigid Disc



Disc-Type and Band-Type Clutches

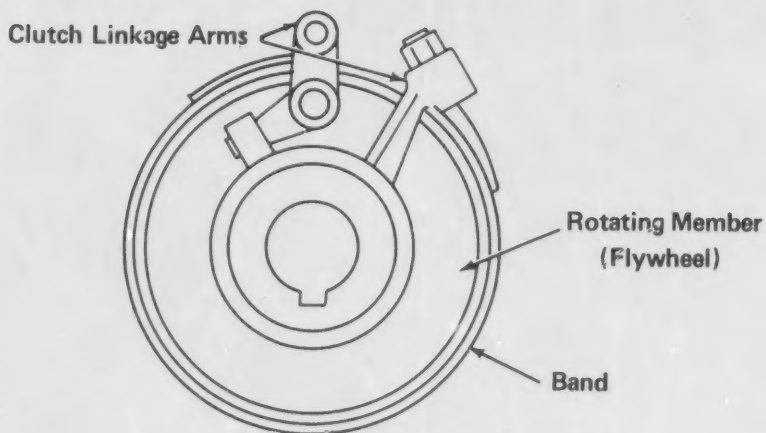


Rigid Disc



Flexible Disc

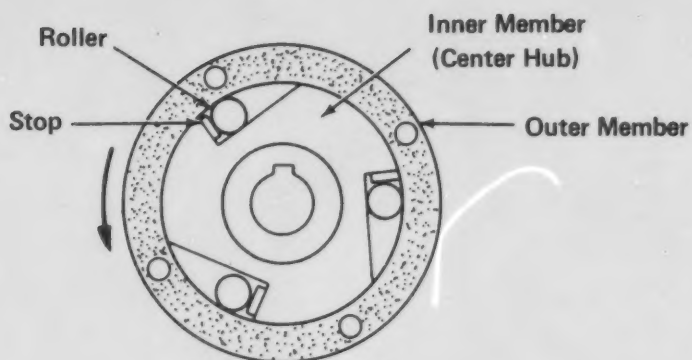
Disc-Type



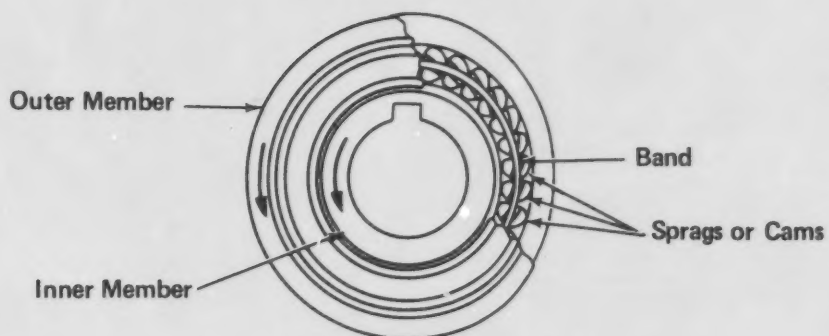
Band-Type

Courtesy DEERE & CO., MOLINE, IL

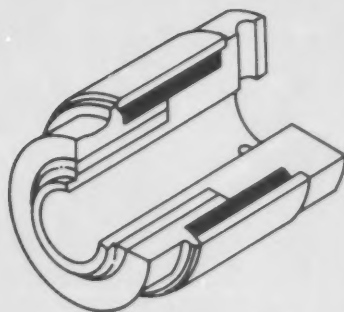
Types of Overrunning Clutches



Roller Clutch



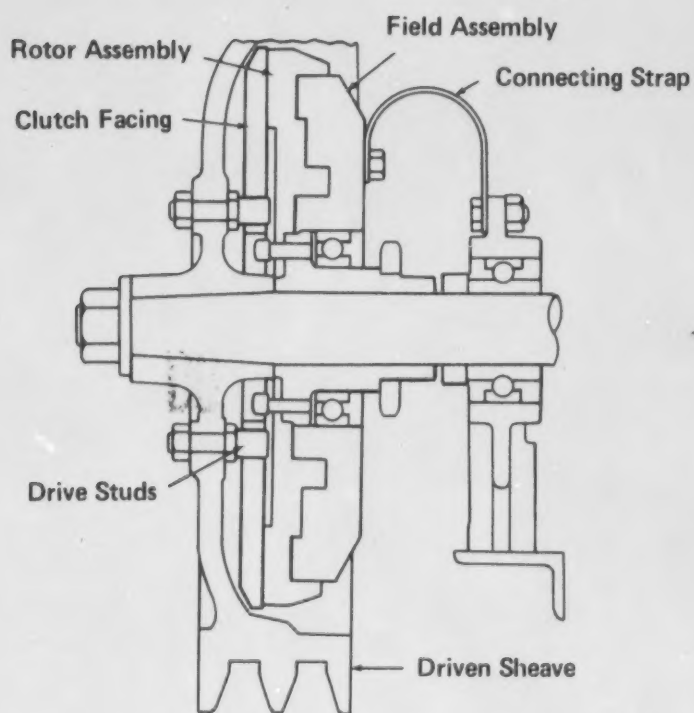
Sprag or Cam Clutch



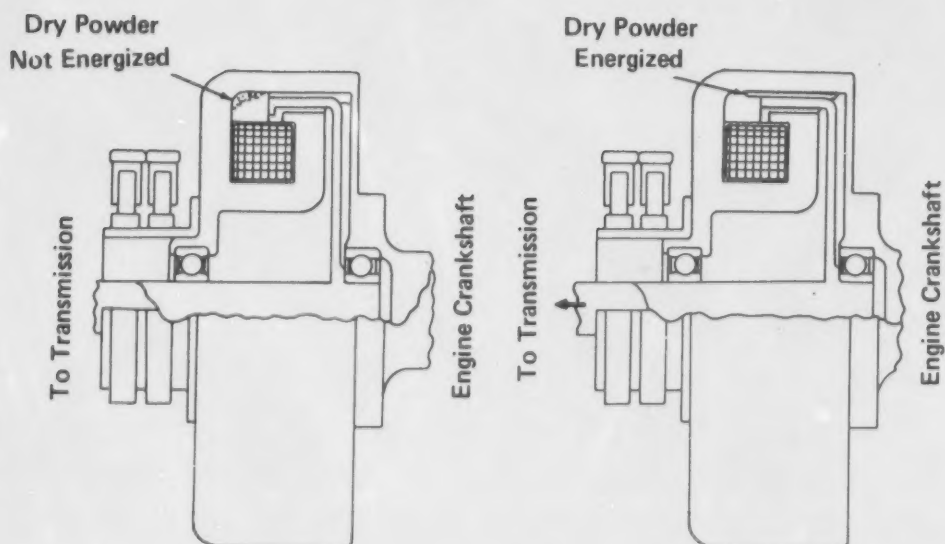
Spring-Type Overrunning Clutch

Courtesy DEERE & CO., MOLINE, IL

Types of Magnetic Clutches



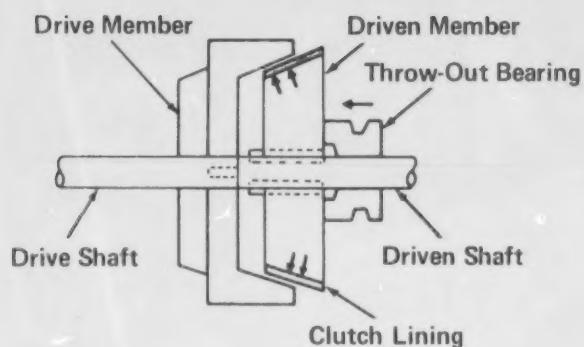
Direct-Action



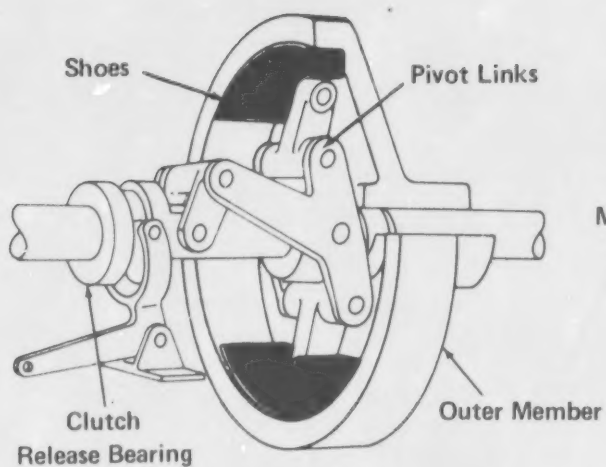
Indirect-Action

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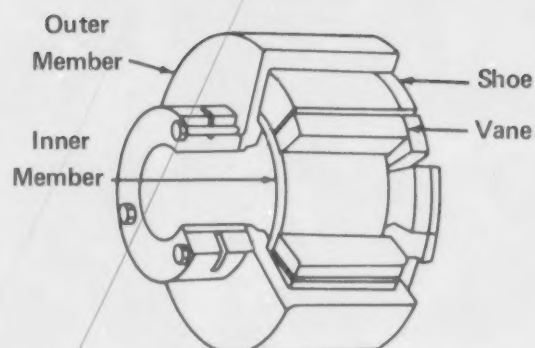
Other Types of Clutches



Cone-Type



**Mechanical -Type
Expanding Shoe**

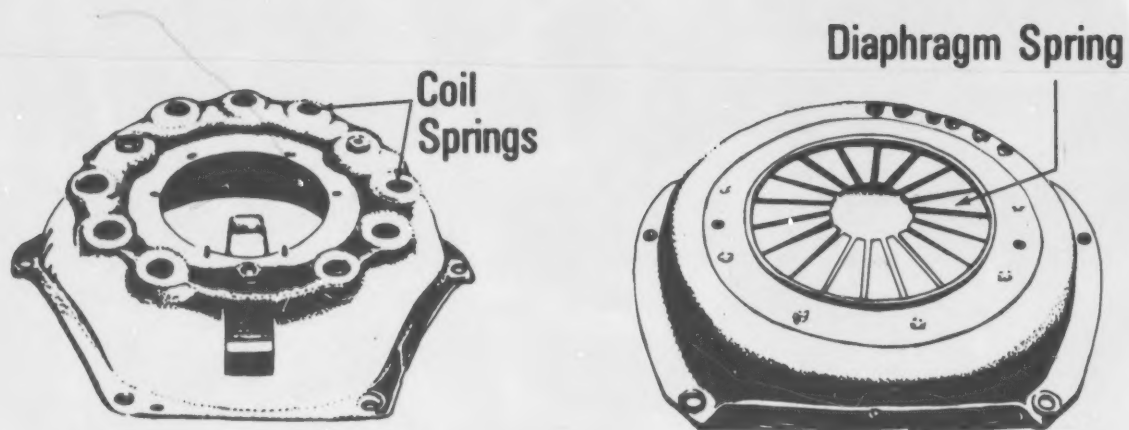


**Centrifugal-Type
Expanding Shoe**

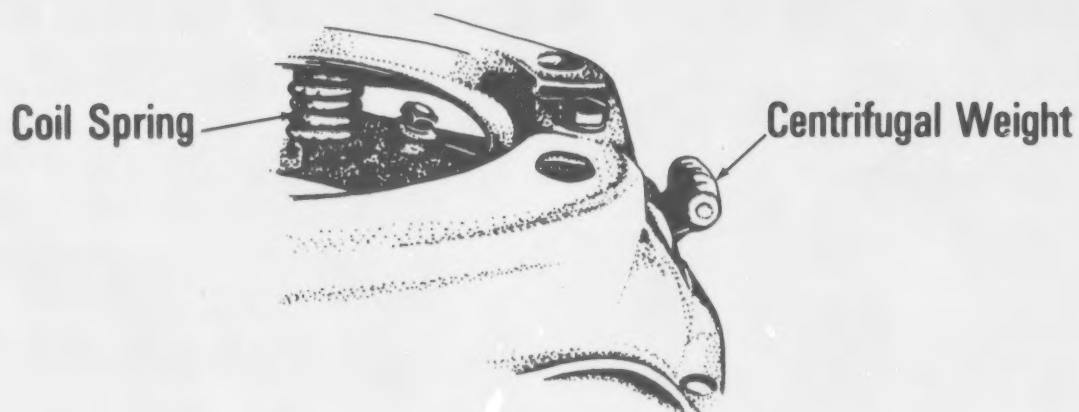
Courtesy DEERE & CO., MOLINE, IL

Types Of Pressure Plates

Coil Spring

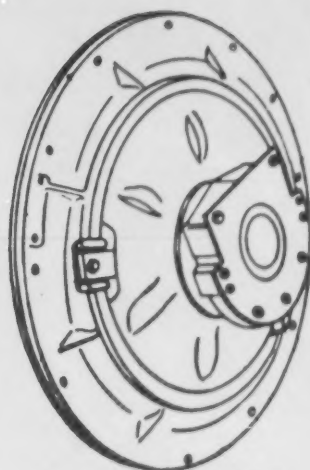


Belleville Spring or Diaphragm

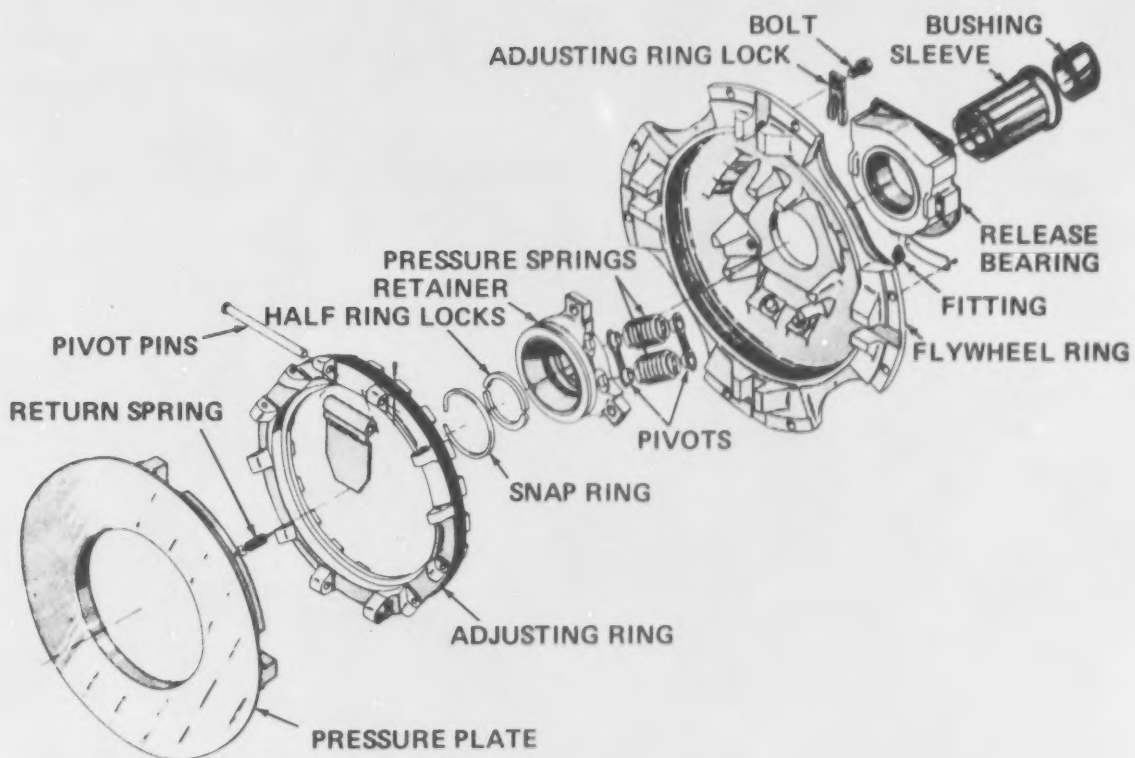


Centrifugal and Coil Spring

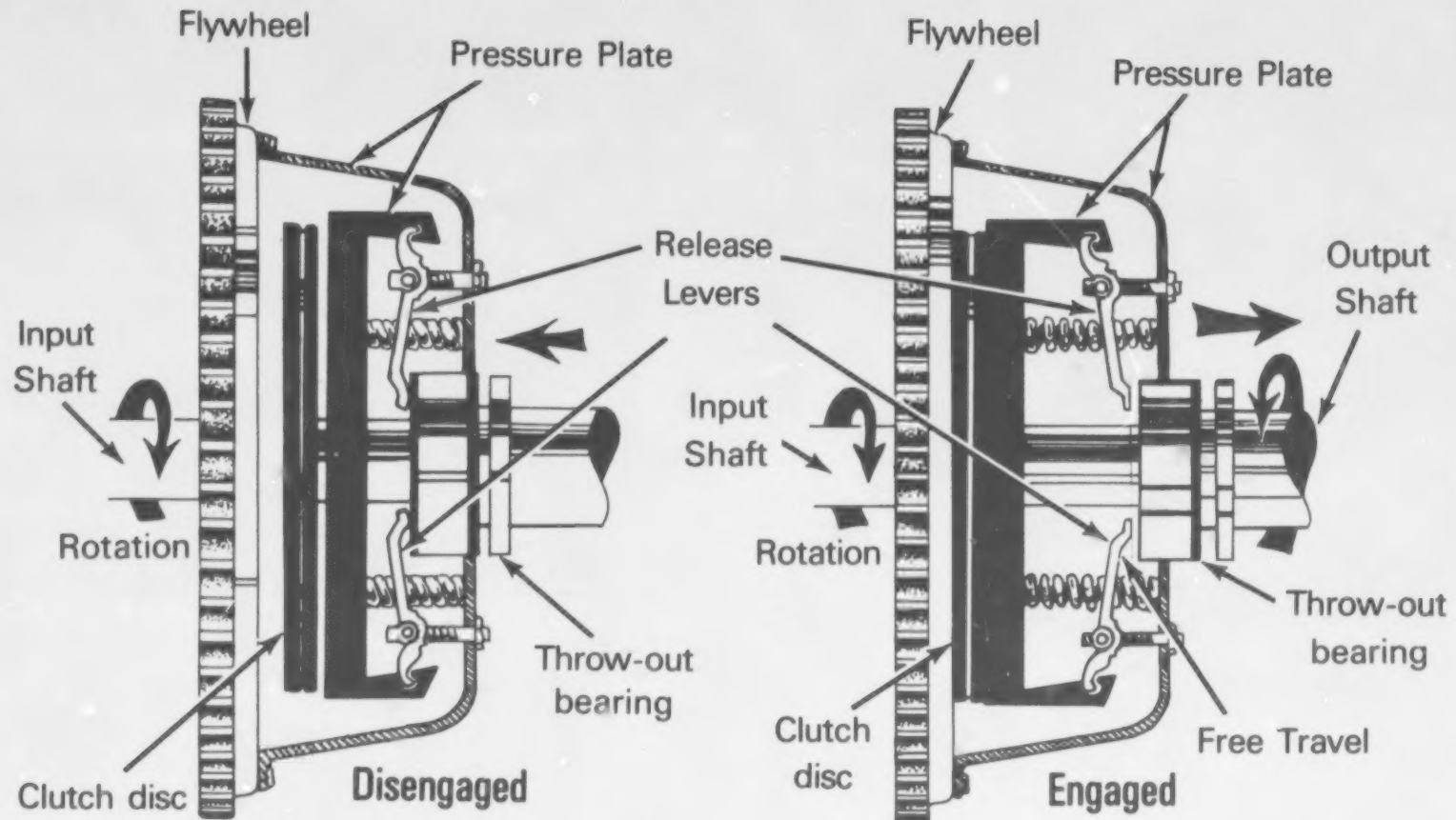
Pull Type Pressure Plate



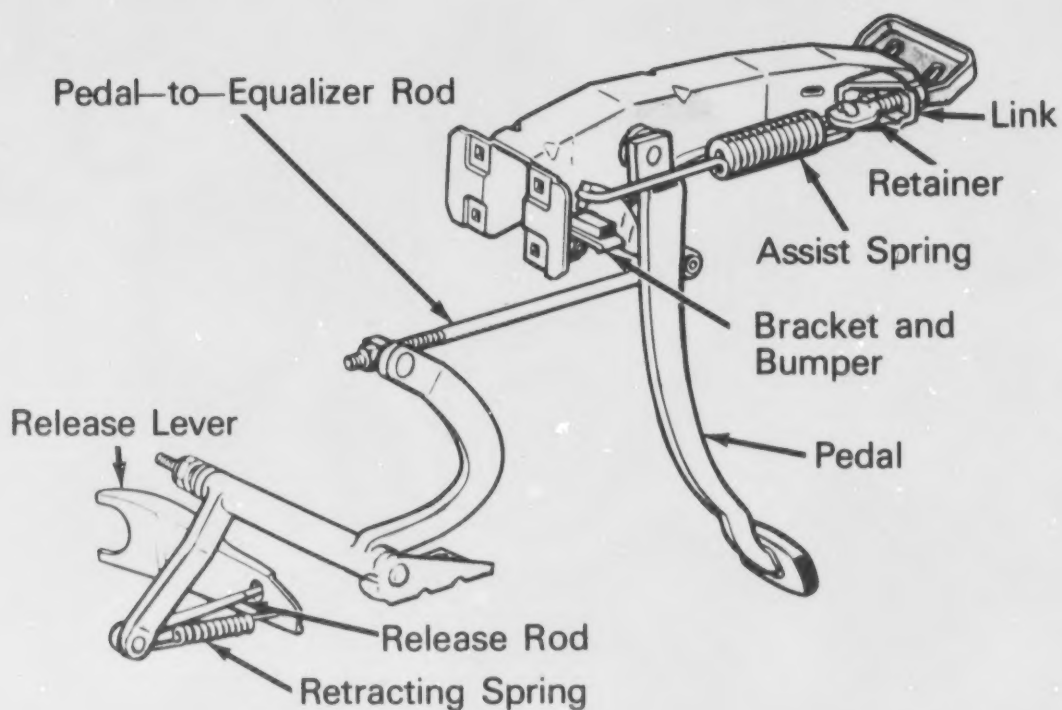
PRESSURE PLATE



Clutch Operation

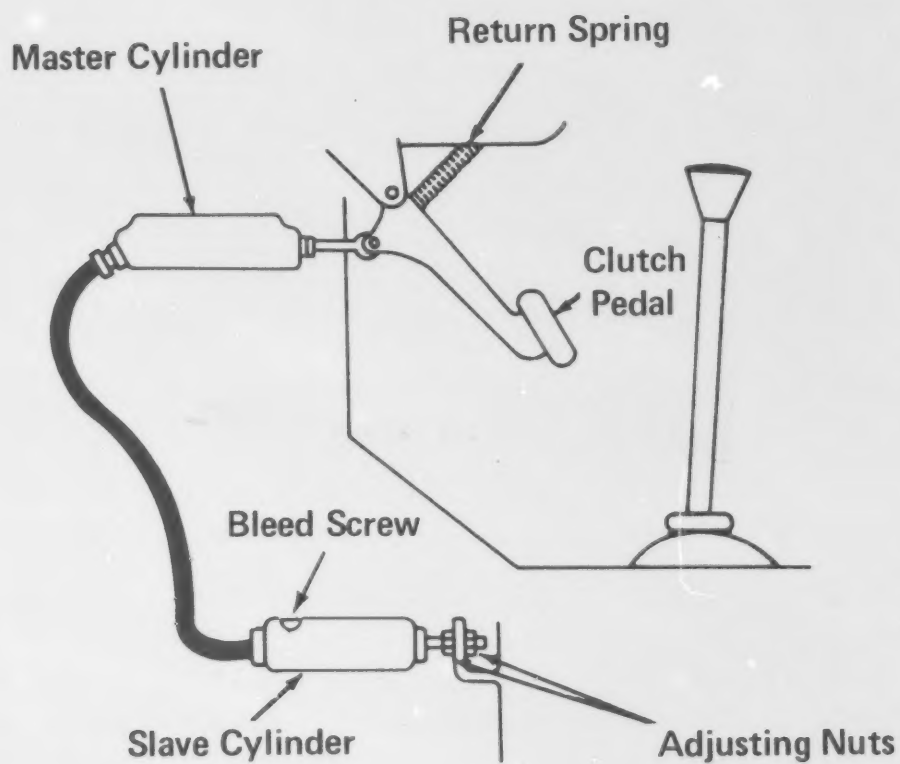


Basic Mechanical Linkage Mechanism



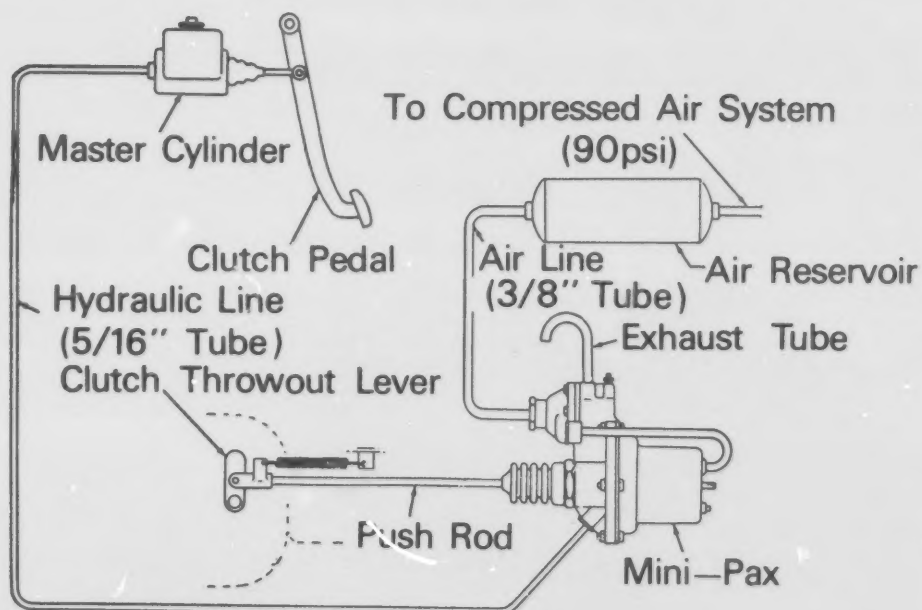
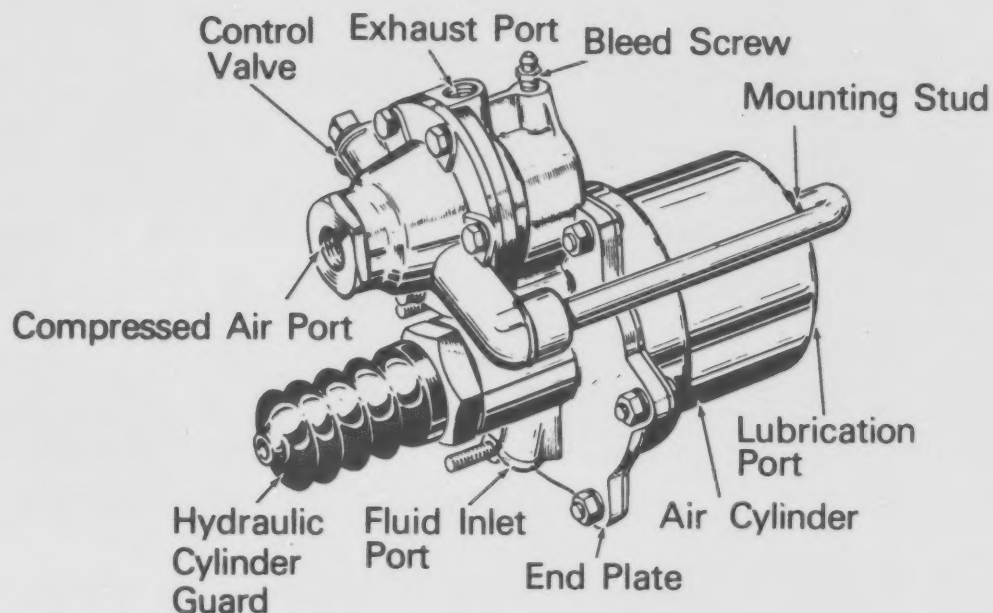
Courtesy Ford Motor Company

Basic Hydraulic System



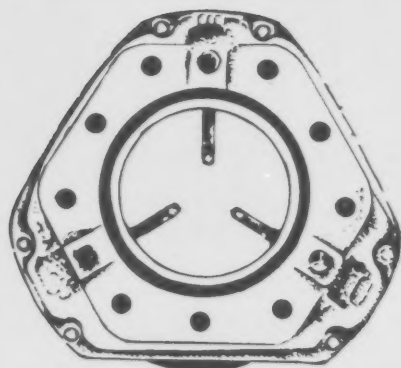
Courtesy DEERE & CO., MOLINE, IL

Basic Air Operated Mechanism

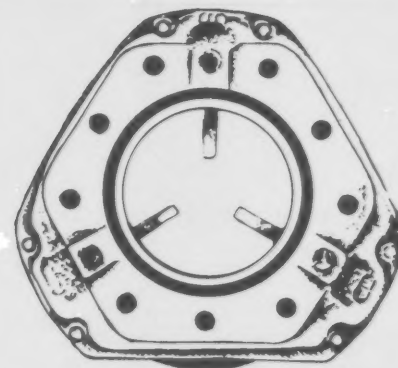


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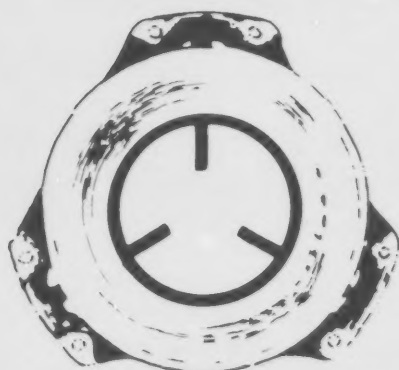
Clutch Inspection



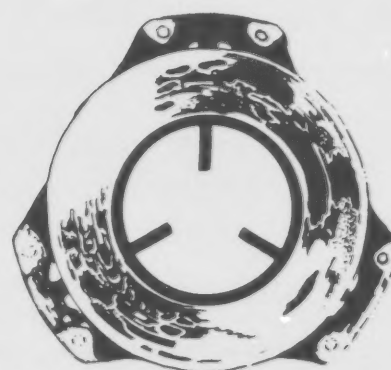
Normal Finger Wear



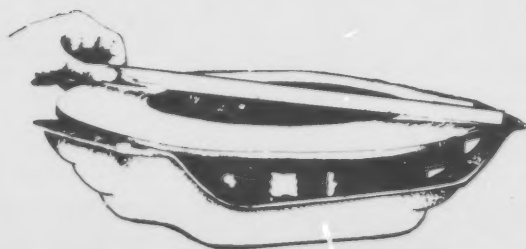
Excessive Finger Wear



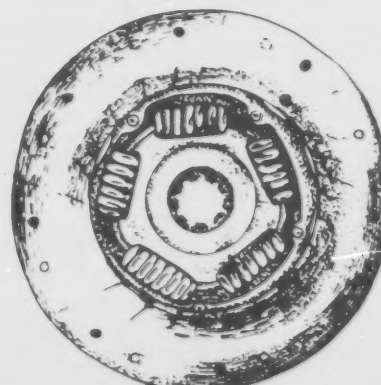
Slight Chatter Marks



Excessive Heat Discoloration



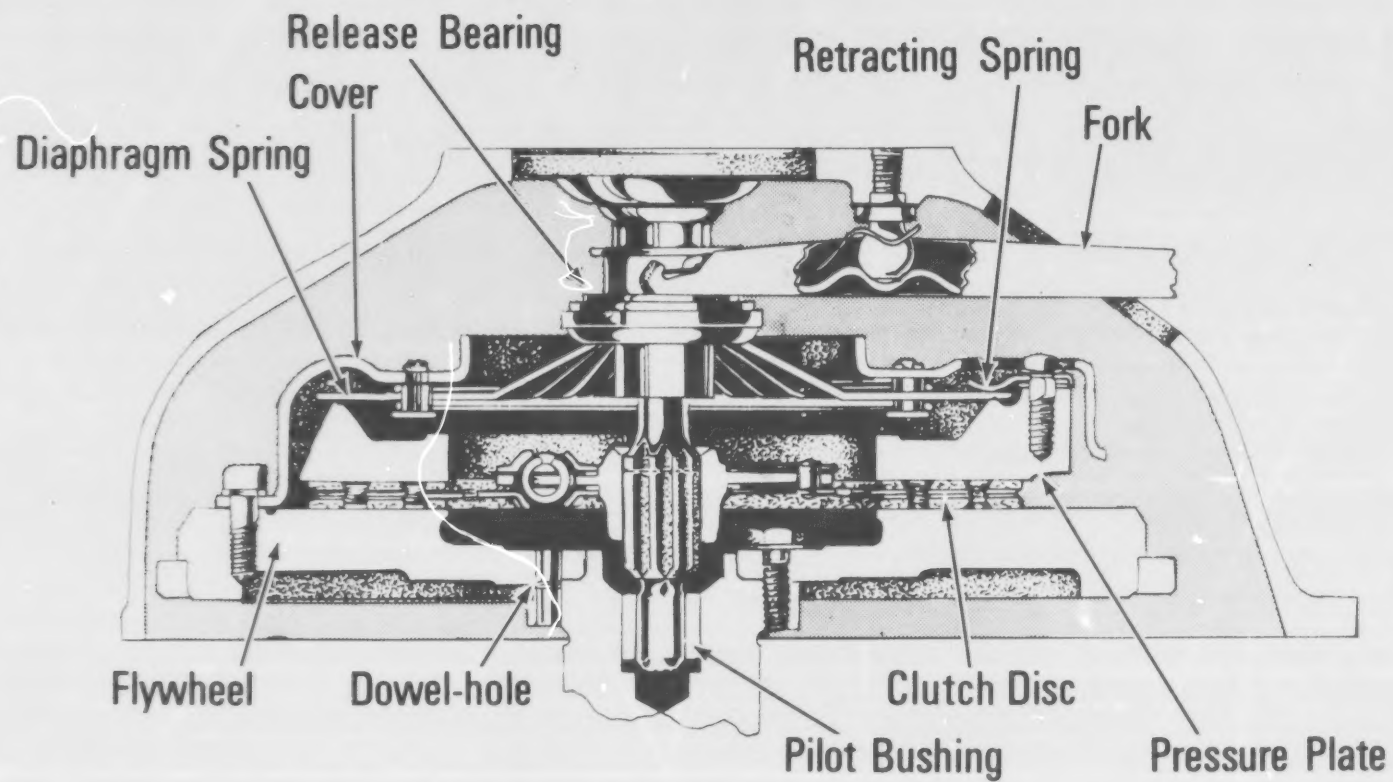
Excessive Warpage



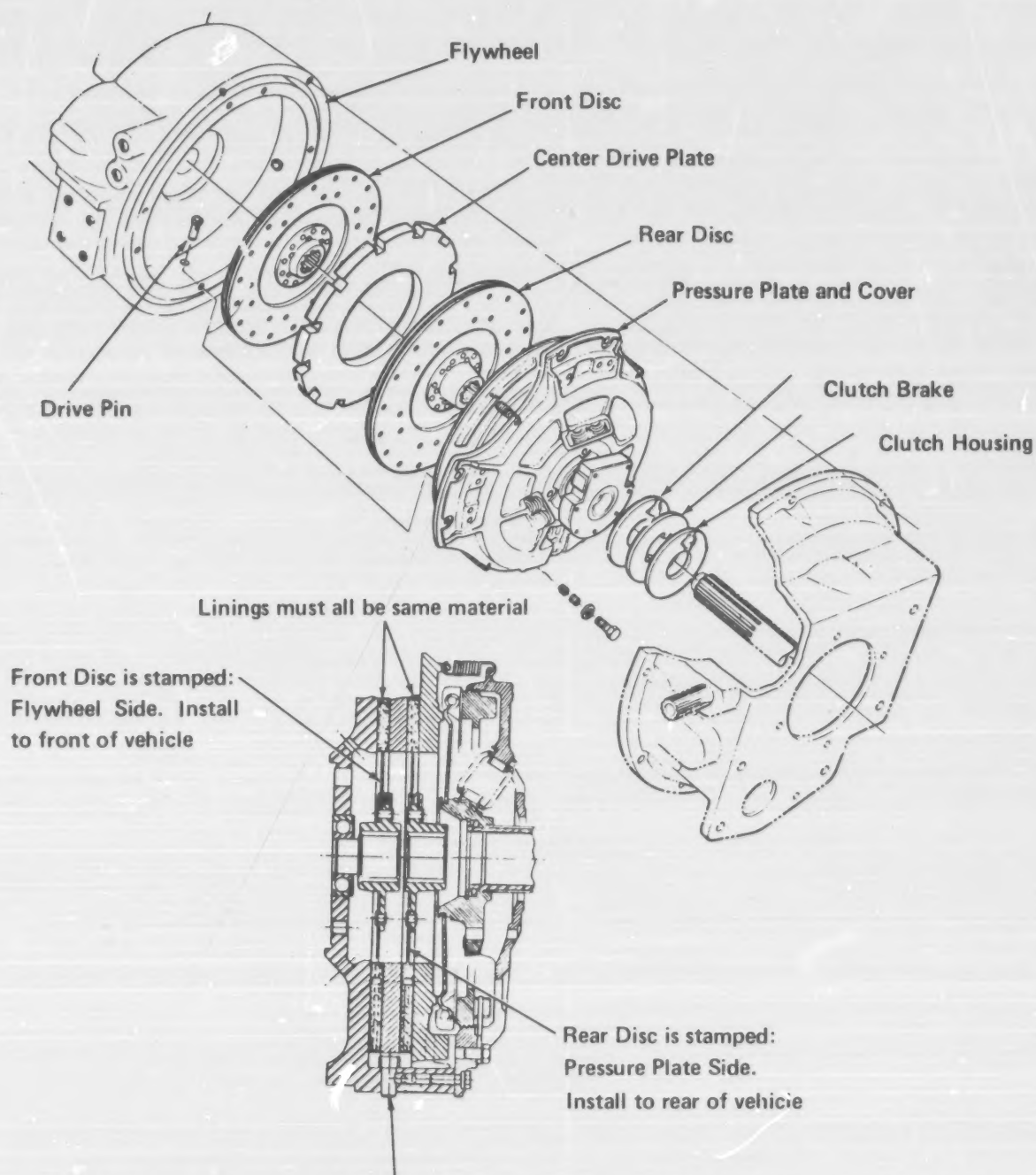
Wear Pattern From Warped Pressure Plate Or Flywheel

Clutch Inspection

(Continued)



Heavy Duty Dual Disc Clutch Components



Drive Pins must be square with Flywheel for proper clearance with notches in Center Drive Plate

Courtesy Ford Motor Company

CLUTCHES AND FLYWHEELS UNIT II

JOB SHEET #1--ADJUST CLUTCH LINKAGE FREE TRAVEL

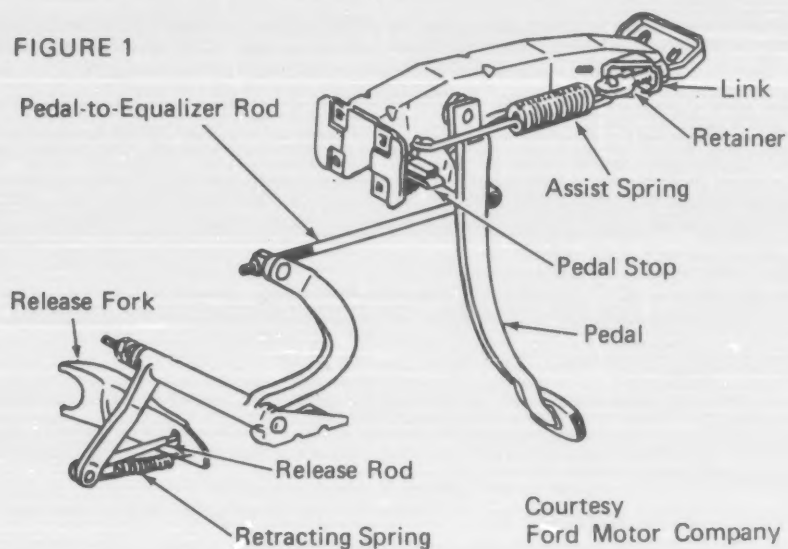
I. Tools and equipment

- A. Basic hand tools
- B. Drop light
- C. Creeper
- D. Floor jack
- E. Wood blocks
- F. Jack stands
- G. Safety glasses

II. Procedure

- A. Make sure clutch pedal returns firmly against pedal stop when released (Figure 1)

FIGURE 1



- B. Locate adjustment on clutch linkage

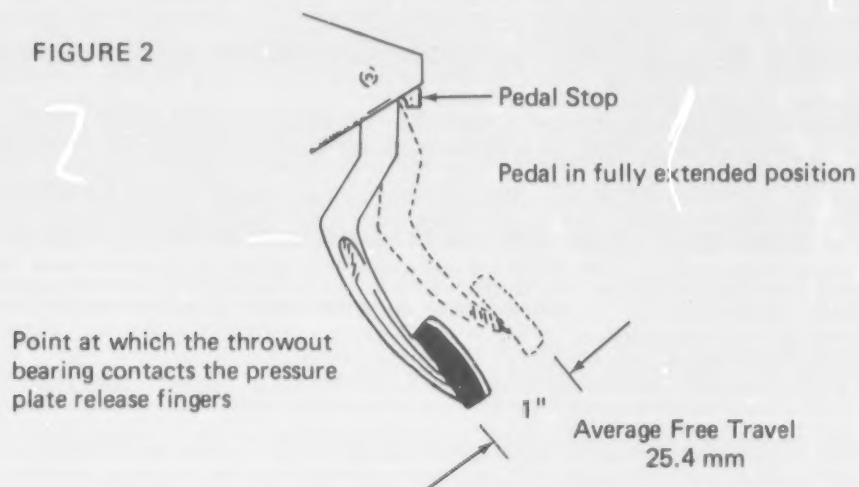
(NOTE: On some vehicles, the clutch adjustment is made under the hood. If adjustment is made under the vehicle and needs to be jacked up, support vehicle on jack stands and block wheels.)

JOB SHEET #1

- C. Check clutch linkages for binding; lubricate as needed
- D. Adjust clutch linkage
- E. Adjust linkage until desired free travel is obtained (Figure 2)

(NOTE: Adjust linkage to manufacturer's specifications. Usually, about one inch of clutch pedal free travel is desired.)

FIGURE 2



- F. Secure locknut on adjuster if so equipped
- G. Remove jack stand if used
- H. Recheck free travel
- I. Remove block from behind wheels

CLUTCHES AND FLYWHEELS UNIT II

JOB SHEET #2--ADJUST FREE TRAVEL ON A PULL TYPE CLUTCH

I. Tools and equipment

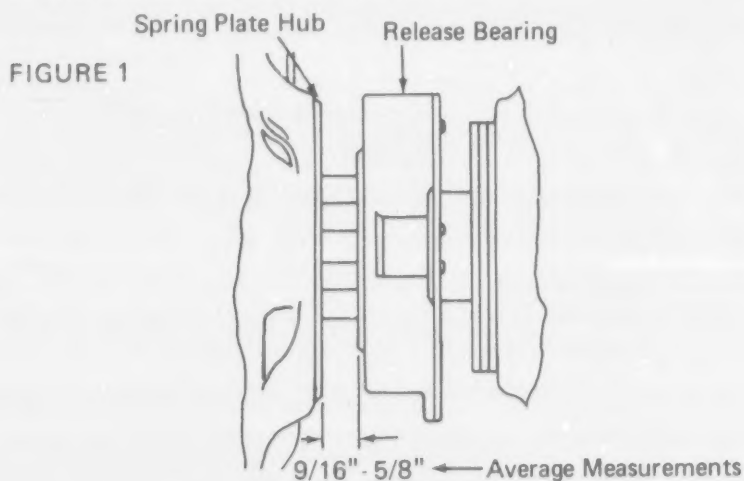
- A. Basic hand tools
- B. Drop light
- C. Creeper
- D. Measuring tape or scale
- E. Clutch adjustment tool
- F. Wood block
- G. Safety glasses

II. Procedure

- A. Block wheels on vehicle
- B. Remove inspection plate on bottom of clutch housing
- C. Disconnect clutch return spring
- D. Hold the release lever against the release bearing

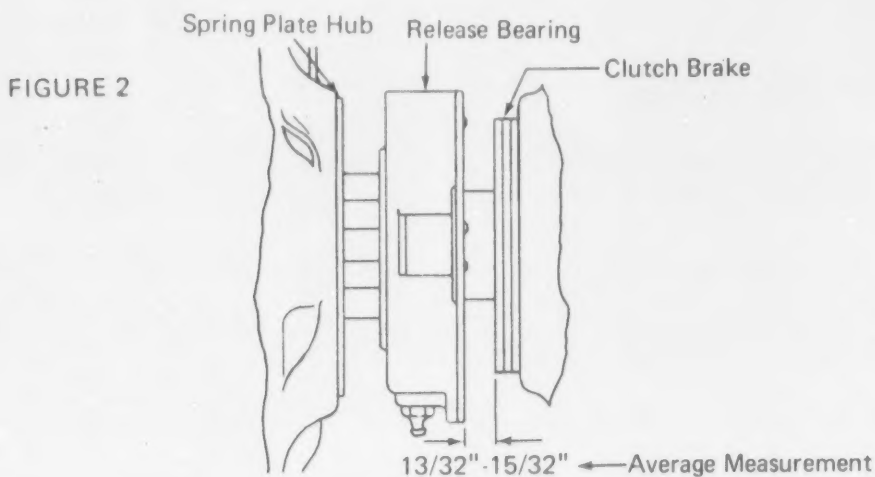
(NOTE: You may have to get someone to hold down on clutch pedal for this operation.)

- E. Measure the distance, on synchronized transmissions, between the release bearing and the clutch spring hub (Figure 1)



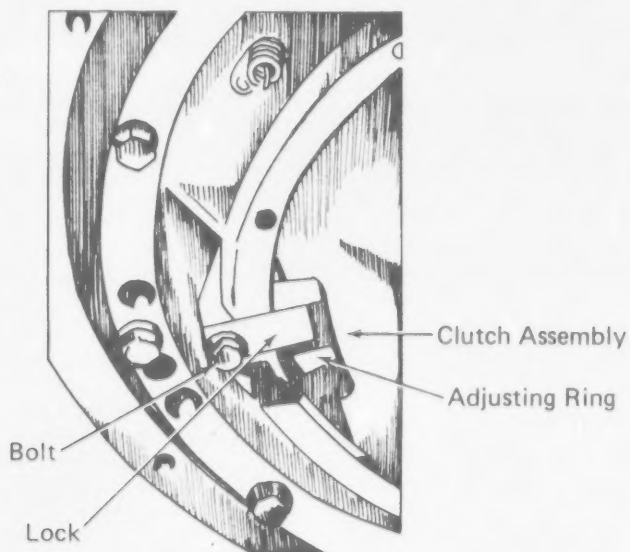
JOB SHEET #2

- F. Check measurement with vehicle manufacturer's specifications
- G. Measure the distance, on nonsynchronized transmissions, between the release bearing and clutch brake (Figure 2)



- H. Check measurement with vehicle manufacturer's specifications
- I. Adjust the check assembly by rotating the engine flywheel until the adjusting lock and bolt come into view (Figure 3)

FIGURE 3



JOB SHEET #2

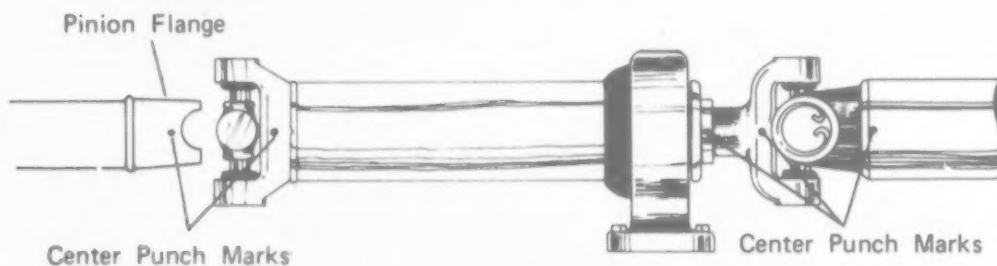
- J. Remove the bolt and lock (Figure 3)
 - K. Have someone hold the clutch pedal down so the clutch is in the release position
 - L. Use a clutch adjusting tool to turn adjusting ring counterclockwise to move the release bearing toward the flywheel, or clockwise to move the release bearing away from the flywheel
 - M. Have the person holding clutch pedal down let up on the pedal to engage the clutch
 - N. Remeasure the clearance as outlined in steps E and G
 - O. Install the lock and bolt if clutch is properly adjusted
 - P. Check clutch pedal free travel
- (CAUTION: Install lock and pin before starting engine.)
- Q. Reinstall inspection plate

CLUTCHES AND FLYWHEELS UNIT II

JOB SHEET #3--REMOVE A CLUTCH ASSEMBLY

- I. Tools and equipment
 - A. Basic hand tools
 - B. Transmission jack
 - C. Engine support stand
 - D. Drop light
 - E. Creeper
 - F. Floor jack (if needed)
 - G. Jack stands (if needed)
 - H. Wood blocks
 - I. Shop towels
 - J. Pilot shaft
 - K. Battery cable pliers
 - L. Safety glasses
- II. Procedure
 - A. Disconnect battery GROUND cable
 - B. Block wheels of vehicle
 - C. Mark propeller shaft (drive shaft) for reinstallation (Figure 1)

FIGURE 1



JOB SHEET #3

- D. Remove propeller shaft
- E. Secure rollers on propeller shaft with tape
- F. Disconnect transmission shift lever mechanisms
- G. Disconnect any electrical, air, or hydraulic connections from transmission
- H. Disconnect speedometer cable
- I. Disconnect rear mount

(NOTE: It may be necessary to support the rear of the engine before transmission removal if the engine does not have a rear engine mount attached.)

- J. Raise transmission just enough to clear any crossmembers or remove crossmembers if necessary
- K. Support rear of engine and raise or lower transmission as necessary
- L. Remove transmission attaching bolts

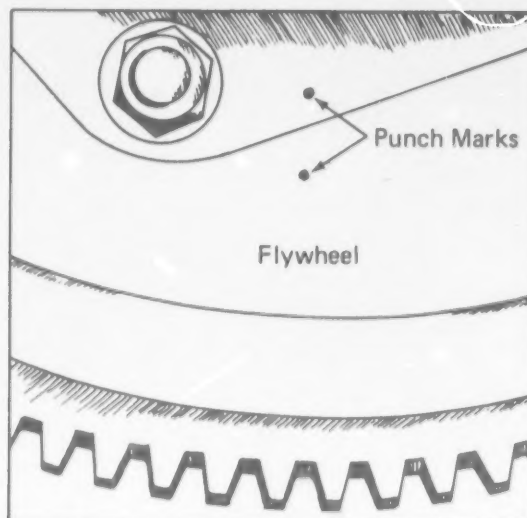
(CAUTION: Secure the transmission to a jack; a transmission is extremely heavy and must be handled safely.)

- M. Remove transmission
- N. Remove clutch release bearings

JOB SHEET #3

- O. Mark flywheel and pressure plate with a center punch while clutch assembly is exposed (Figure 2)

FIGURE 2



- P. Remove pressure plate attaching bolts

(CAUTION: A clutch adjustment tool should be placed through the clutch disc and pressure plate to prevent them from falling as the attaching bolts are removed.)

- Q. Remove clutch and pressure plate

(NOTE: While removing clutch disc, notice the position of the disc when removed.)

(CAUTION: Pressure plates can be extremely heavy; keep your feet out from under the plate when working with it.)

CLUTCHES AND FLYWHEELS UNIT II

JOB SHEET #4--INSPECT A CLUTCH DISC

I. Tools and equipment

- A. Solvent container
- B. Solvent
- C. Brush
- D. Drop light
- E. Shop towels
- F. Safety glasses

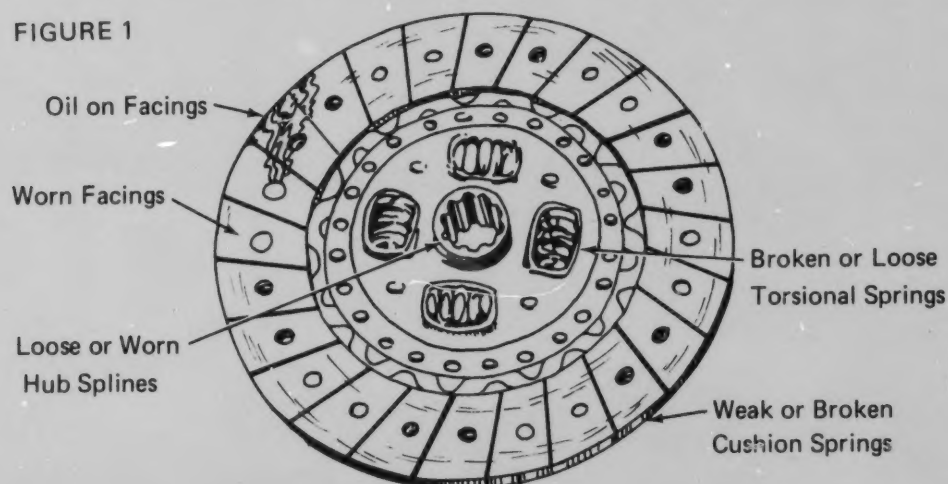
II. Procedure

- A. Wash pressure plate and clutch housing in suitable solvent

(CAUTION: Do not wash release bearing in solvent because it would wash out lubricant and ruin bearing. Do not wash a nonmetallic clutch disc in solvent because the facings would be damaged.)

- B. Inspect the flywheel for scoring and roughness
- C. Inspect the pressure plate for scoring, roughness, and broken springs
- D. Inspect the clutch disc for wear or damage (Figure 1)

FIGURE 1



- E. Inspect clutch release bearing for excessive wear on contact face; check for roughness of balls and races

CLUTCHES AND FLYWHEELS UNIT II

JOB SHEET #5--CHECK A CLUTCH HOUSING ALIGNMENT

I. Tools and equipment

- A. Dial indicator
- B. "C" clamp
- C. Torque wrench
- D. Basic shop tools
- E. Shop towels
- F. Safety glasses

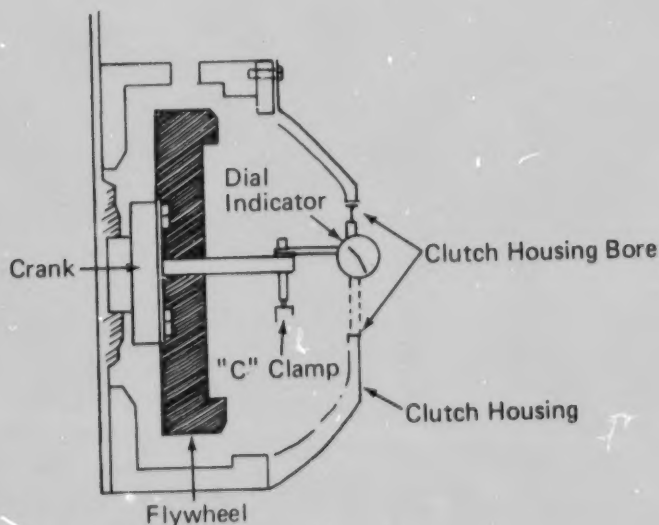
II. Procedure

(NOTE: This procedure is accomplished with the transmission and clutch assembly removed. The clutch housing bore and transmission mating surface should be clean.)

A. Check bore runout

1. Replace one flywheel-to-crank-shaft bolt with a bolt about 3" long (Figure 1)

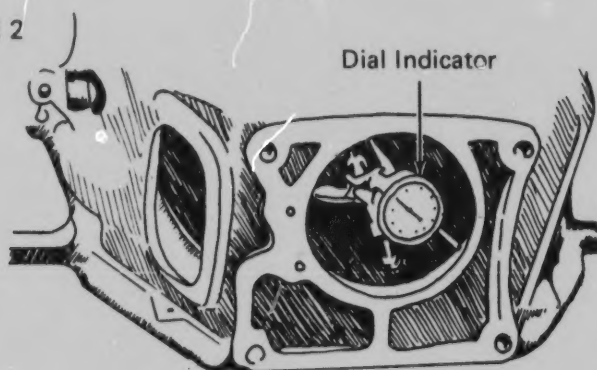
FIGURE 1



JOB SHEET #5

2. Mount a dial indicator on this bolt (Figure 2)

FIGURE 2



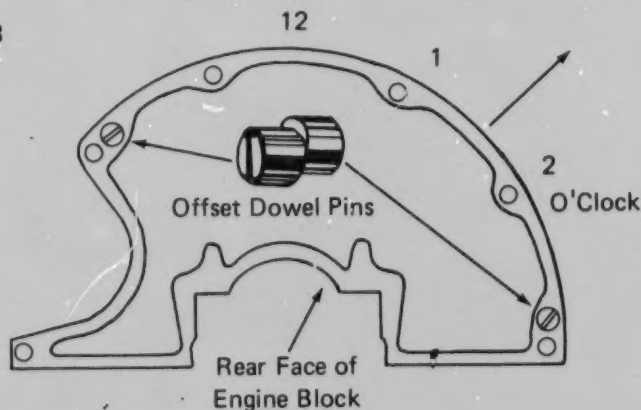
Measuring Housing Bore Runout

(NOTE: The dial indicator contact should set squarely on the bore wall.)

3. Adjust the dial to "0"
4. Rotate engine clockwise with a socket wrench on vibration damper bolt at front of crankshaft
5. Record dial indicator needle deflection (Figure 3)

(NOTE: Check the runout with the allowable runout found in the service manual for the particular vehicle being repaired. Excessive bore runout can be corrected by installing correct size of offset dowel pins.)

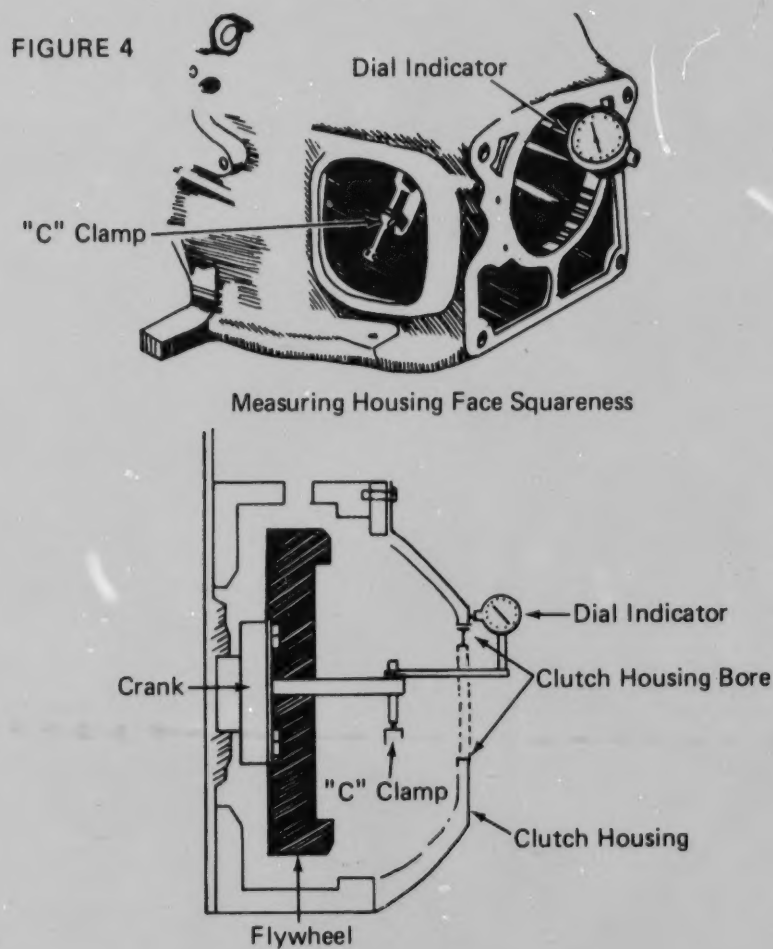
FIGURE 3



JOB SHEET #5

B. Check face squareness

1. Position dial indicator so the contact will ride squarely on the transmission mating surface of the clutch housing (Figure 4)



2. Adjust the dial to "0"
3. Rotate the engine clockwise with a socket wrench on vibration damper bolt at front of crankshaft

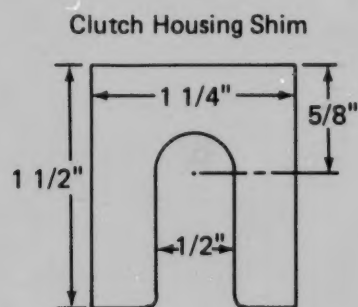
JOB SHEET #5

4. Record dial indicator reading

(NOTE: If total indicator reading is greater than allowed in the service manual for the vehicle being repaired, locate the point of the lowest reading.)

5. Place shims on the side where the lowest reading was made (Figure 5)

FIGURE 5



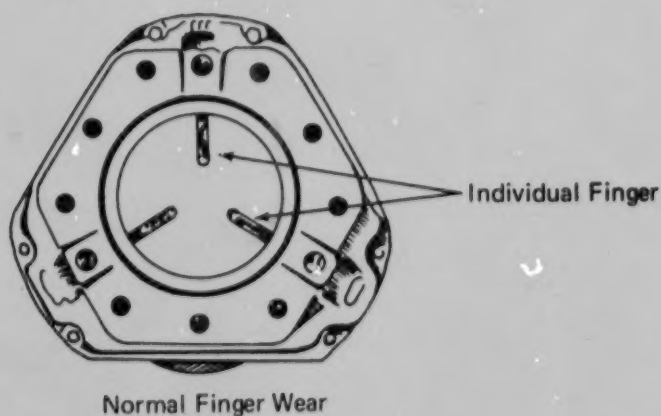
6. Not more than 0.010 inches of shims should be placed between the engine and clutch housing
7. If the housing cannot be brought into alignment, replace the housing

CLUTCHES AND FLYWHEELS UNIT II

JOB SHEET #6-INSPECT A PRESSURE PLATE AND COVER

- I. Tools and equipment
 - A. Shop towels
 - B. Drop light
 - C. Solvent container
 - D. Solvent
 - E. Brush
 - F. Safety glasses
- II. Procedure
 - A. Place shop towels on bench, and place pressure plate on towels being careful not to score or scratch the machine surface
 - B. Force each individual finger down, and then release it quickly (Figure 1)

FIGURE 1

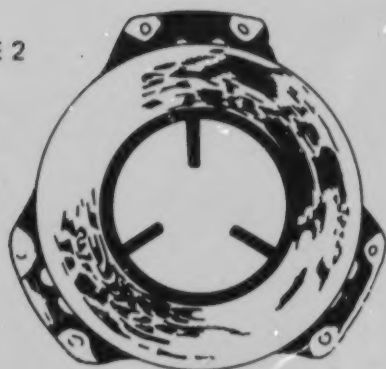


- C. Check to see if finger does not return quickly; this indicates a binding condition and the pressure plate should be replaced
- D. Inspect the surface of the pressure plate for burn marks, scores, flatness, or ridges (Figures 2 and 3)

(NOTE: If pressure plate is badly heat-checked or deeply scored, replace the pressure plate and cover assembly.)

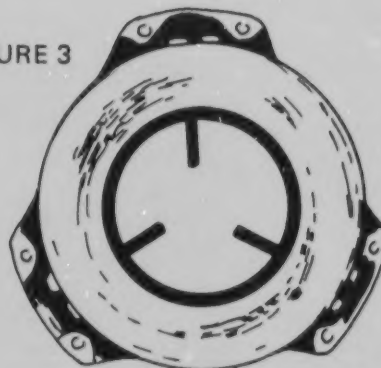
JOB SHEET #6

FIGURE 2



Excessive Heat Discoloration

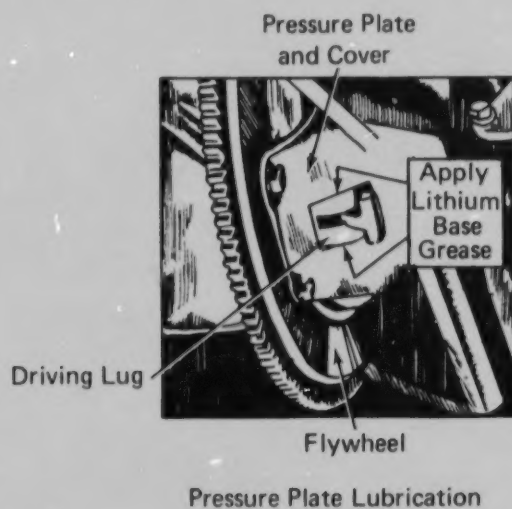
FIGURE 3



Slight Chatter Marks

- E. Clean the pressure plate and flywheel surfaces with suitable commercial solvent to be sure the surfaces are free from any oil film
- F. Lubricate the pressure plate lightly with molly-lube grease between the driving lugs and edges of the pressure plates as shown in Figure 4

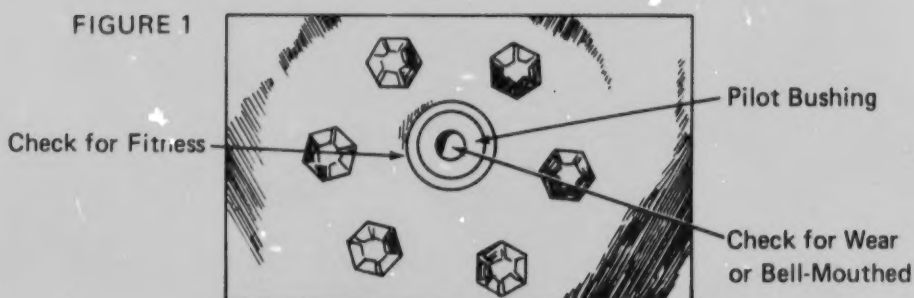
FIGURE 4



CLUTCHES AND FLYWHEELS UNIT II

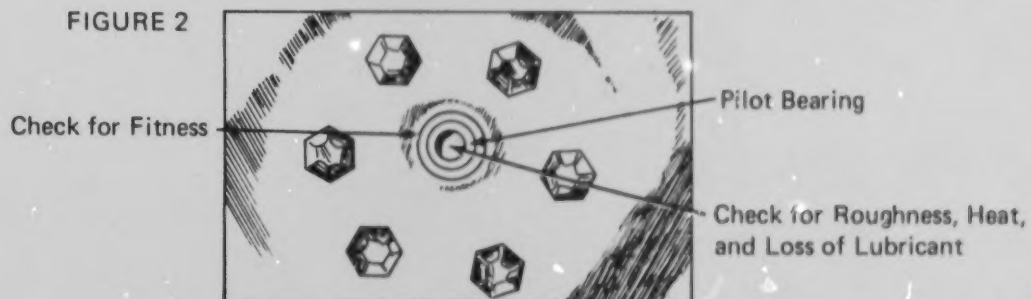
JOB SHEET #7--INSPECT A PILOT BEARING AND PILOT BUSHING

- I. Tools and equipment
 - A. Basic shop tools
 - B. Drop light
 - C. Shop towels
 - D. Safety glasses
- II. Procedure
 - A. Check the fit of the clutch pilot bushing and pilot bearing in the bore of the crankshaft or flywheel
 - B. Check to see that bushing or bearing is pressed into crankshaft and not loose
 - C. Inspect the inner surface of the bushing for wear or a bell-mouthed condition (Figure 1)



JOB SHEET #7

- D. Inspect the pilot bearing for roughness while rotating, evidence of overheating or loss of lubricant (Figure 2)



(NOTE: On checking lubricant for bushing and bearing, check manufacturer's specification because some require lubricant and some do not need it.)

(CAUTION: If you do lubricate a bushing or bearing, avoid using too much lubricant because it may be thrown onto the clutch disc when the clutch revolves.)

CLUTCHES AND FLYWHEELS UNIT II

JOB SHEET #8--REINSTALL A CLUTCH ASSEMBLY

I. Tools and equipment

- A. Basic hand tools
- B. Engine support stand
- C. Floor jack (if needed)
- D. Jack stands (if needed)
- E. Transmission jack
- F. Clutch disc alignment tool

(NOTE: A transmission input shaft may be used for clutch alignment.)

- G. Torque wrench
- H. Safety glasses

II. Procedure

- A. Clean flywheel friction surface
- B. Check to make sure the recess in the crankshaft is absolutely clean before installing a new pilot bearing or bushing

(CAUTION: When installing a pilot bearing, keep the shielded side of bearing toward the transmission or away from the flywheel.)

- C. Apply a small amount of grease to pilot bearing

(CAUTION: Refer to the service manual for the vehicle being repaired for lubricant procedures.)

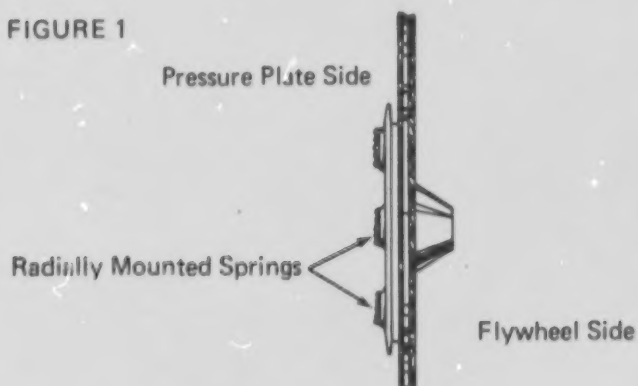
- D. Start bearing by hand, tap into place by striking the outer race
- E. Check to make sure the friction surface of pressure plate and flywheel are clean before installing the clutch assembly

JOB SHEET #8

- F. Place the clutch disc in the mounting position with the radially mounted springs away from the flywheel (Figure 1)

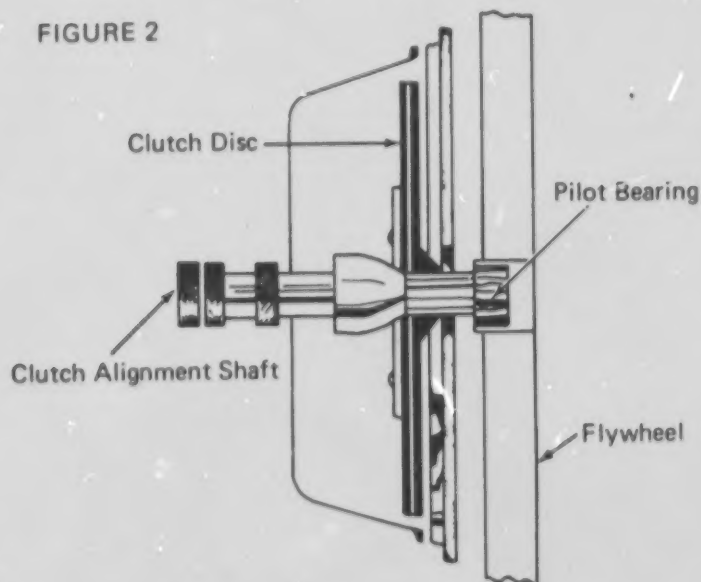
(CAUTION: Refer to service manual on some clutches as they may go the other way.)

FIGURE 1



- G. Position pressure plate over the clutch disc
- H. Install clutch alignment shaft through the pressure plate and clutch disc and align into the pilot bearing (Figure 2)

FIGURE 2



JOB SHEET #8

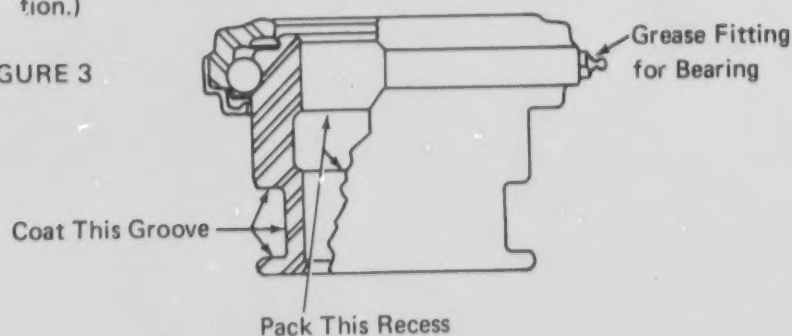
- I. Align center punch marks on pressure plate and flywheel
- J. Start pressure plate attaching bolts and lock washers
(NOTE: Make sure bolts are the correct type and shouldered.)
- K. Tighten bolts alternately a few turns at a time until they are snug

(CAUTION: Do not tighten one bolt at a time.)

- L. Torque bolts to manufacturer's specifications
- M. Remove clutch alignment shaft
- N. Lubricate release bearing and sleeve (Figure 3)

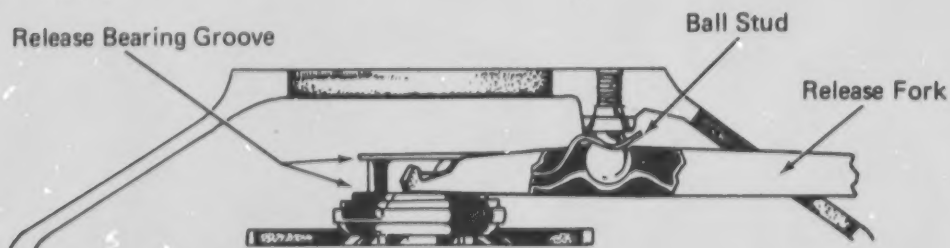
(NOTE: Check manufacturer's specifications; some may not require lubrication.)

FIGURE 3



- O. Make sure release fork is in place (Figure 4)

FIGURE 4



JOB SHEET #8

P. Install transmission

(NOTE: Use a transmission jack and guide pins to avoid clutch disc damage during transmission installation.)

(CAUTION: Do not allow transmission weight to hang on clutch disc.)

Q. Connect clutch linkage

R. Attach shifting linkage

S. Install speedometer cable

T. Install rear mount and cross-member, if applicable

U. Install drive shaft while aligning marks

V. Check free travel; adjust if necessary

(NOTE: Refer to Job Sheet #1 if necessary.)

W. Connect battery ground cable

X. Remove jack stands if used

Y. Remove block from behind wheels

CLUTCHES AND FLYWHEELS UNIT II

JOB SHEET #9--REMOVE, INSPECT, REPAIR, AND REINSTALL A 15 1/2-INCH DUAL DISC CLUTCH

I. Tools and equipment

- A. Basic shop tools
- B. Press
- C. Clean shop towels
- D. Aligning tool or old transmission main drive gear
- E. Two 3/4-inch blocks of wood
- F. Two 7/16-inch 14NC (5" long) guide studs
- G. Pilot bearing remover
- H. Slide hammer
- I. Piece of 2 1/2-inch OD tubing
- J. Piece of 2 x 4 to make bridge
- K. High temperature lubricant
- L. Chain hoist
- M. 100 foot-pound torque wrench
- N. Safety glasses

II. Procedure

(NOTE: This procedure is adapted from materials published and copyrighted by General Motors Corporation, and relate specifically to the Spicer 15 1/2-inch dual disc angle-spring clutch; your instructor may modify the procedure to facilitate a different or a smaller dual disc clutch.)

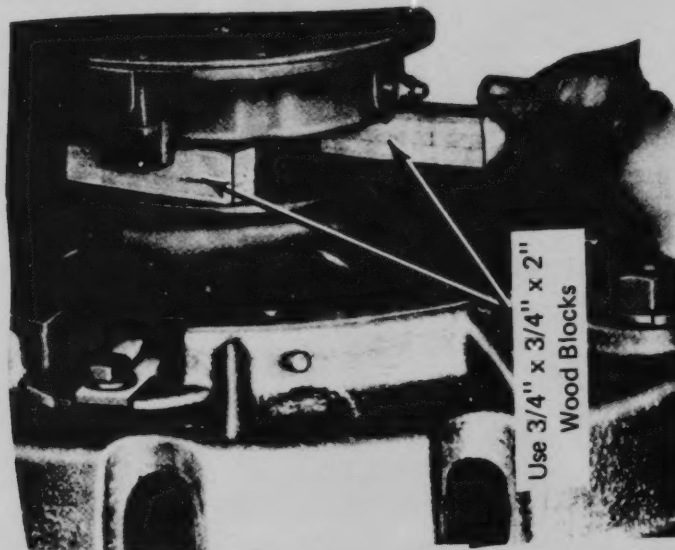
- A. Remove transmission assembly from vehicle as directed in the manufacturer's service manual
- B. Remove the clutch assembly with the following procedure:
 - 1. Install aligning tool or an old transmission main drive gear into the hubs of the driven discs to support the clutch assembly during removal

JOB SHEET #9

2. Install two 3/4-inch blocks of wood between the front of clutch release bearing and clutch spring plate hub (Figure 1)

(NOTE: The wood blocks will relieve the heavy internal spring load, preventing the clutch from cocking during removal.)

FIGURE 1



3. Mark flywheel ring in relation to engine flywheel to assure original positioning at reassembly, if either part is to be reused
4. Remove two upper clutch-to-flywheel mounting bolts and insert, in their place, two 7/16" -14NC (5" long) guide studs
5. Loosen the clutch-to-flywheel cap screws, alternating one turn at a time to avoid creating undue stresses in flywheel ring
6. When all clutch-to-flywheel mounting bolts have been removed, slide clutch assembly back on studs, using caution to prevent dropping of front disc or intermediate drive plate
7. Rig a sling with a small chain to assist in lowering the clutch from assembly studs to floor

(CAUTION: The Spicer 15 1/2-inch clutch assembly weighs approximately 150 pounds.)

8. Remove clutch assembly from vehicle and lower to floor

JOB SHEET #9

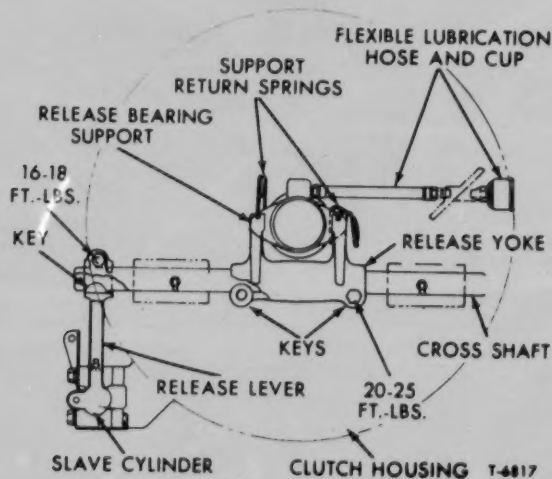
- C. Stop at this point and have your instructor check and initial your procedure and safe practice

INSTRUCTOR CHECK: Procedure ☐ Safety ☐ Initials ☐

- D. Inspect and repair yoke-type clutch release mechanism with the following procedure:

1. Check release bearing for roughness or noise by rotating bearing race while applying light pressure
2. Replace bearing if it is rough, noisy, or obviously damaged
3. Remove release lever from clutch release yoke cross shaft (Figure 2)

FIGURE 2



4. Disconnect flexible lubrication tube from top of release bearing support (refer to Figure 2 for the remaining steps in this procedure)
5. Remove two retaining springs from top of bearing support
6. Slide release bearing and support assembly off end of transmission bearing cap
7. Remove two cap screws which attach release yoke to cross shaft, then drive the yoke to one side to expose two drive keys
8. Remove keys, then drive shaft out of yoke and remove from the housing

JOB SHEET #9

- E. Stop at this point and have your instructor check and initial your procedure and safe practice

INSTRUCTOR CHECK: Procedure ☐ Safety ☐ Initials ☐

- F. Reassemble the clutch release mechanism with the following procedure (refer to Figure 2 for all steps):

1. Hold clutch release yoke in position in clutch housing, then insert release cross shaft through one side of clutch housing, through release yoke, and out through opposite side of housing
2. Install two keys in cross shaft, then move yoke into place with keys engaging keyway in yoke
3. Do not tighten bolts until after release bearing and support assembly is assembled to bearing cap
4. Examine contact buttons on ears of bearing support for worn condition; buttons can be pressed out or into support, if necessary
5. Slide release bearing and support assembly on bearing cap to contact fingers of release yoke
6. Install retaining springs, then connect lubrication tube to top of support
7. Check cross shaft and yoke to make sure they are properly centered, then tighten yoke clamp bolts
8. Install release lever on yoke cross shaft with drive key in slot of shaft
9. Position lever on shaft so that it is directly in line with center of slave cylinder push rod
10. Tighten lever clamp bolt firmly
11. Fill grease cup with lubricant as specified in service manual, and lubricate clutch cross shaft bushings, using fitting at each side of clutch housing

- G. Stop at this point and have your instructor check and initial your procedure and safe practice

INSTRUCTOR CHECK: Procedure ☐ Safety ☐ Initials ☐

JOB SHEET #9

H. Inspect, remove, and reinstall clutch pilot bearing with the following procedure:

1. Inspect for corrosion or roughness on either the race or the balls by rotating the bearing inner race with a finger
2. Remove clutch pilot bearing assembly from engine, using pilot bearing remover J-5901-2 with slide hammer J-2619
3. With fingers on puller closed, insert fingers through bearing inner race as far as they will go, then tighten thumb screw to spread fingers
4. Slide weight sharply against stop on puller shaft to remove bearing
5. Pack clutch pilot bearing with small quantity of high temperature lubricant as specified in service manual
6. With shielded side of bearing toward the rear, drive pilot bearing into position, using a rawhide mallet or a block of wood
7. Inspect bearing to make sure it is seated firmly

I. Stop at this point and have your instructor check and initial your procedure and safe practice

INSTRUCTOR CHECK: Procedure ☐ Safety ☐ Initials ☐

J. Inspect flywheel, intermediate drive plate, pressure plate, and driven discs with the following procedures:

1. Inspect surface which is contacted by the clutch facing
2. Make sure surface is smooth; it should not be grooved or show deep heat checks
3. Replace if any of the above conditions are evident
4. Inspect driven disc assembly for worn, loose, and grease or oil-soaked facings
5. Check for broken springs, loose rivets, or cracks in the driven disc hub
6. Examine splines in hub for wear and make sure they slide freely on splines of the main drive gear
7. If any wear or damage is evident, replace with a new driven disc assembly

JOB SHEET #9

- K. Stop at this point and have your instructor check and initial your procedure and safe practice

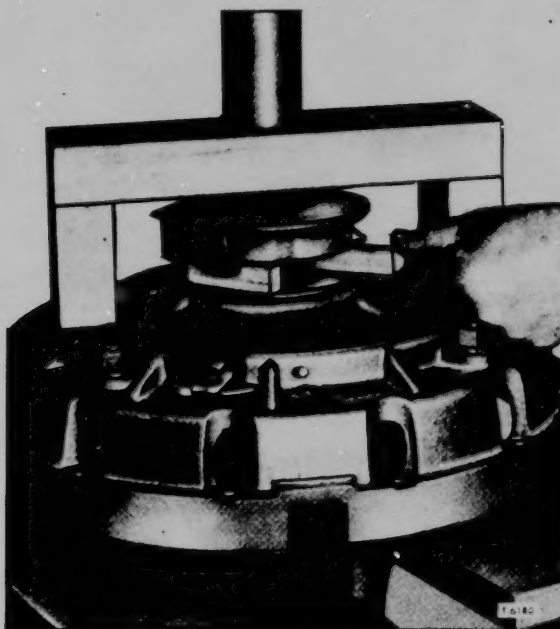
INSTRUCTOR CHECK: Procedure ☐ Safety ☐ Initials ☐

- L. Inspect and repair pressure plate and cover assembly as directed by your instructor

- M. Reinstall the clutch assembly with the following procedure

1. If wood blocks have not been installed between the release bearing and spring plate hub, perform the following:
 - a. Turn clutch assembly over on bed of arbor press and rest end of release sleeve on piece of 2 1/2-inch OD tubing
 - b. Use the 2 x 4 bridge as shown in Figure 3 to compress the pressure springs and install the two 3/4-inch blocks between the release bearing and spring plate hub

FIGURE 3



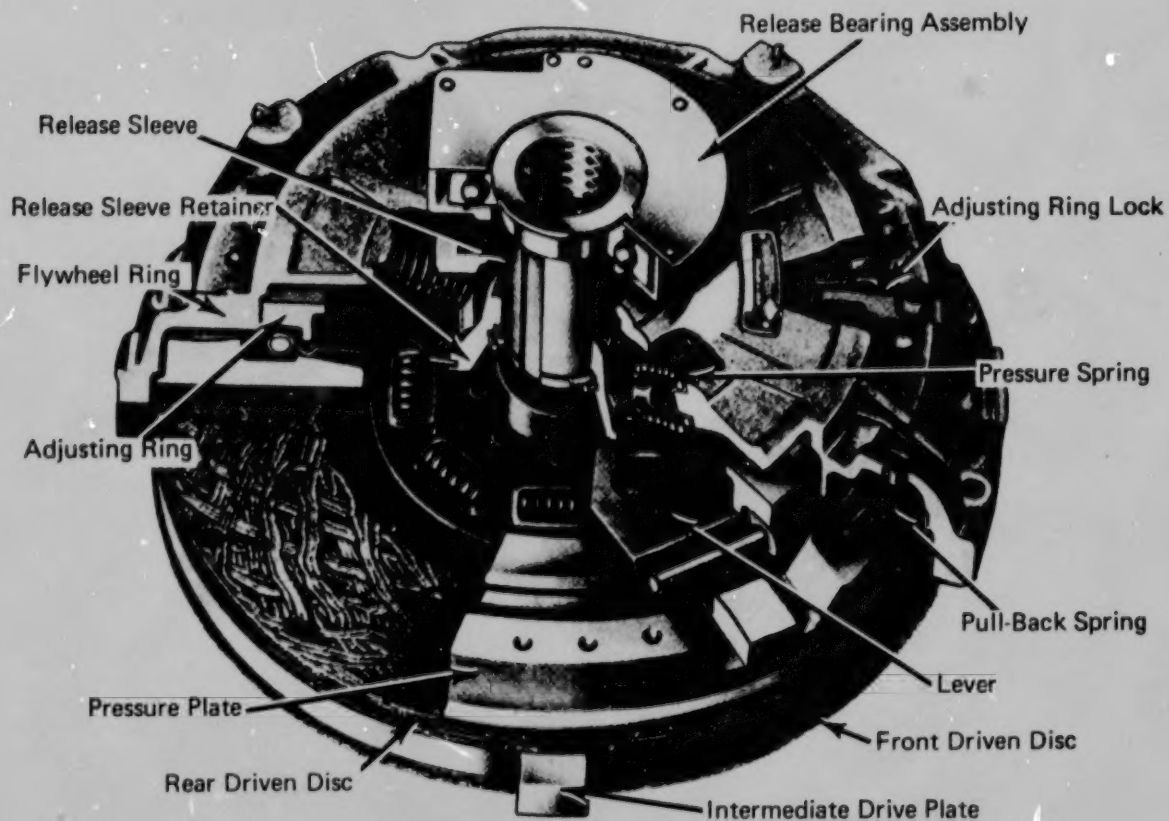
2. Insert two 7/16"-14NC (5" long) guide studs into two upper mounting holes of the flywheel

JOB SHEET #9

3. Slide clutch disc aligning tool or a transmission main drive gear, through release bearing sleeve and assemble rear drive disc

(NOTE: When placing driven disc on aligning tool, be sure the exposed portion of the disc damper springs face the pressure plate as shown in Figure 4)

FIGURE 4



JOB SHEET #9

4. Place intermediate plate in flywheel ring, aligning driving lugs of plate with slots provided
5. Place front driven disc assembly on aligning tool with exposed portion of disc damper springs facing the pressure plate
6. Position clutch assembly under flywheel and use a small chain hoist to jack or lift the clutch assembly into position on the two assembly guide studs

(NOTE: If alignment marks were made on flywheel ring and flywheel prior to removal, align these before lifting clutch into position on guide studs.)

7. Slide clutch assembly forward and position in flywheel pilot
8. Start ten retaining cap screws with lock washers and run in finger tight
9. Tap clutch disc aligning tool in to make sure it has entered and centered in the pilot bearing
10. Remove the two guide studs and insert two remaining cap screws and lock washers
11. Progressively tighten all cap screws to 35-40 ft lb torque

(CAUTION: Do not try to pull the clutch into place by running one cap screw completely down with an impact wrench; this procedure can crack or break the pilot shoulders, causing off-square mounting and out-of-balance conditions.)

12. As the cap screws are tightened, the 3/4-inch wooden blocks should fall free; if they do not, remove the blocks at this time and the clutch aligning tool
 13. Install clutch brake (fiber washer, steel tang washer, and a second fiber washer) on the transmission main drive gear
 14. Install transmission assembly as directed in manufacturer's service manual
 15. Adjust clutch controls as directed in manufacturer's service manual
- N. Stop at this point and have your instructor check and initial your procedure and safe practice

INSTRUCTOR CHECK: Procedure ☐ Safety ☐ Initials ☐

CLUTCHES AND FLYWHEELS UNIT II

JOB SHEET #10--DISSASSEMBLE, INSPECT, AND REASSEMBLE A HYDRAULIC (WET-TYPE) CLUTCH

- I. Tools and equipment
 - A. Basic hand tools
 - B. Lint-free cleaning cloths
 - C. Tool T 65 I-77515-A (Ford)
 - D. Cape chisel
 - E. Awl
 - F. Press
 - G. Tool T 66 L-7003-B4 and handle (Ford)
 - H. Clean transmission fluid
 - I. Clearance gauge
 - J. New bushing, new inner seal, new outer seal
 - K. Tool 7000-DD (Ford)
 - L. Compressed air supply

- II. Procedure

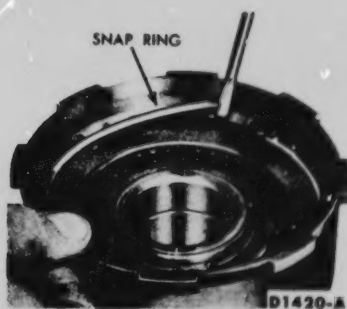
(NOTE: The following procedure and illustrations are adapted from materials published by Ford Service Publications© 1968 by Ford Motor Company, and are reprinted with permission; the procedure may be modified by your instructor to facilitate available equipment.)

- A. Prepare component for disassembly of reverse-high clutch as directed by your instructor

JOB SHEET #10

- B. Remove the pressure plate retaining snap ring from the reverse-high clutch (Figure 1)

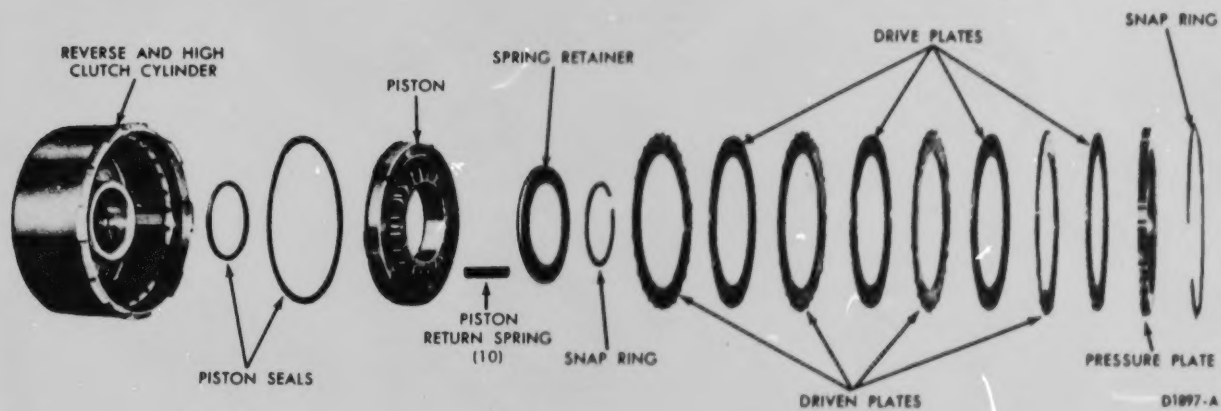
FIGURE 1



- C. Remove the pressure plate and the drive and driven clutch plates (Figure 2)

(NOTE: If the composition plates are to be re-used, they must not be cleaned in a vapor degreaser or with a detergent solution; wipe them clean with a lint-free cloth.)

FIGURE 2

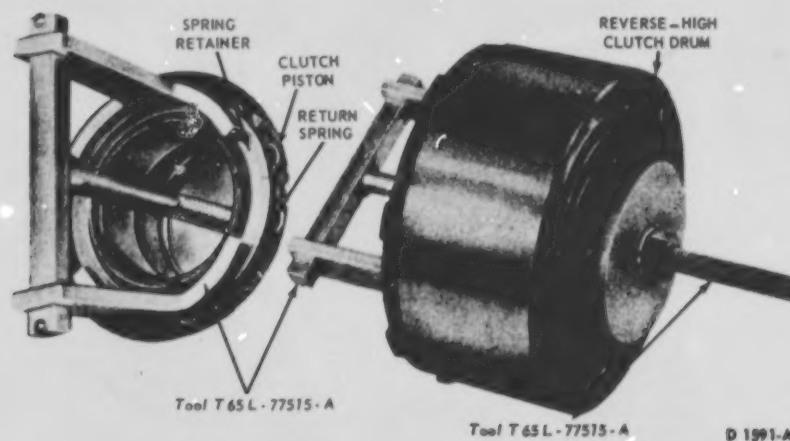


JOB SHEET #10

- D. Remove the piston spring retainer snap ring by compressing the piston return springs with the tool shown in Figure 3, and remove the snap ring

(NOTE: As the tool is released, guide the spring retainer to clear the snap ring groove of the drum.)

FIGURE 3

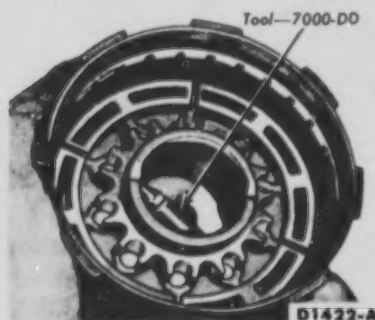


- E. Remove the spring retainer and 10 piston return springs

(NOTE: It is important to remember the location of the piston return springs because they must be reassembled in the same places from which they are removed.)

- F. Remove the piston by inserting air pressure in the piston apply hole of the clutch hub (Figure 4)

FIGURE 4



- G. Remove the piston outer seal from the piston and piston inner seal from the clutch drum (refer to Figure 2)

JOB SHEET #10

- H. Inspect drum bushing, and if it is worn or damaged, remove it
- I. Use the cape chisel to cut a shallow groove 3/4 inch in length along the bushing seam until the chisel breaks through the bushing wall (Figure 5)

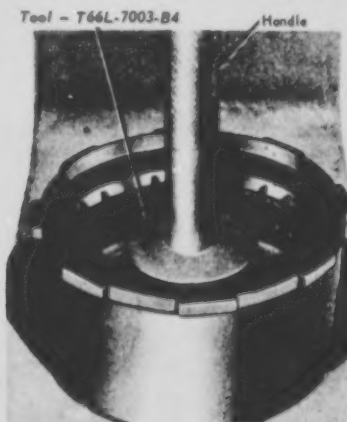
(CAUTION: To prevent leakage at the stator support O-rings, be careful not to nick or damage the hub surface with the chisel.)

FIGURE 5



- J. Pry the loose ends of the bushing up with an awl and remove the bushing
- K. Position the drum in a press, and press a new bushing into the drum with the handle and tool shown in Figure 6

FIGURE 6



- L. Install a new inner seal in the clutch drum and a new outer seal on the clutch piston (refer to Figure 2)
- M. Lubricate the seals with clean transmission fluid
- N. Install the piston into the clutch drum
- O. Place the 10 clutch piston into position on the clutch piston

(NOTE: The clutch piston springs must be placed back exactly where they came from.)

JOB SHEET #10

- P. Place the snap ring retainer on top of the springs
- Q. Install the snap ring retainer with the tool shown in Figure 3, and as you press down, make sure the spring retainer is centered to clear the drum
- R. Install the snap ring, and before releasing the tool, make sure the snap ring is positioned inside of the four snap ring guides on the spring retainer
- S. Install the clutch plates alternately, starting with a steel plate, then a non-metallic plate; the last plate installed is the pressure plate (refer to Figure 2)

(NOTE: For the correct number of clutch plates required for each transmission, check manufacturer's specifications, and if new drive plates are installed, soak them in automatic transmission fluid for 15 minutes before assembling them in the clutch drum.)

- T. Install the pressure plate retaining snap ring
- U. Hold the snap ring down and check reverse-high clutch snap ring clearance with a clearance gauge to make sure clearance is 0.050 to 0.0066 inch (Figure 7)

(NOTE: If the clearance is not within specifications, check manufacturers specifications for a selective-thickness snap ring that will bring the clearance within specifications.)

FIGURE 7



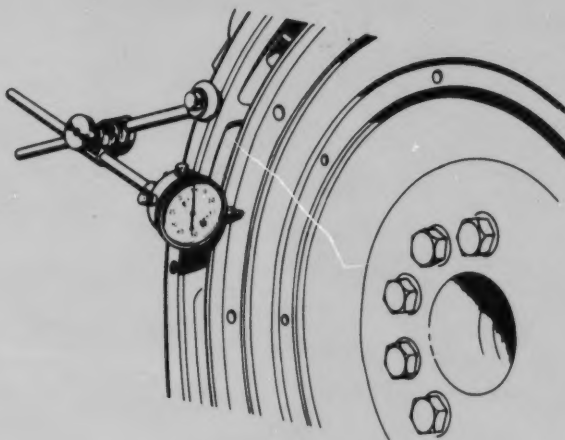
- V. Have your instructor check your work
- W. Return tools and materials to proper storage areas

CLUTCHES AND FLYWHEELS UNIT II

JOB SHEET #11--CHECK FLYWHEEL RUNOUT

- I. Tools and equipment
 - A. Basic hand tools
 - B. Shop towels
 - C. Dial indicator
 - D. Wire brush
 - E. Safety glasses
- II. Procedure
 - A. Clean clutch contact surface and rim edge of flywheel
 - B. Set up dial indicator (Figure 1)

FIGURE 1



Courtesy Caterpillar

- C. Rotate the flywheel to determine the amount of runout and check to see if it is within manufacturer's specifications

(NOTE: Hold crankshaft in one direction while turning to prevent end play from affecting reading.)
- D. Check both clutch disc contact surface and rim edge (Figure 1), and check both with manufacturer's specifications

CLUTCHES AND FLYWHEELS UNIT II

JOB SHEET #12--REMOVE AND REPLACE A FLYWHEEL RING GEAR

I. Tools and equipment

- A. Basic hand tools
- B. Wire brush
- C. Acetylene torch
- D. Wood block
- E. Safety glasses

II. Procedure

- A. Support the flywheel, ring gear side down, on a solid flat surface of wood block which is slightly smaller than inside diameter of the ring gear

(NOTE: Check to see if ring gear teeth are chamfered [have beveled edges], and place new ring gear in same direction.)

- B. Drive the ring gear off the flywheel with a suitable drift and hammer

(CAUTION: Do not strike the flywheel.)

- C. Work around the circumference of the gear to avoid binding of the gear on the flywheel

(NOTE: Some ring gears may have to be heated for removal.)

- D. If heat was used to remove ring gear, allow flywheel to cool and turn flywheel over on a solid flat surface

- E. Rest ring gear on a fire brick surface

(NOTE: Never heat on a concrete floor.)

- F. Heat the gear uniformly with an acetylene torch, keeping the torch moving around the gear to avoid hot spots

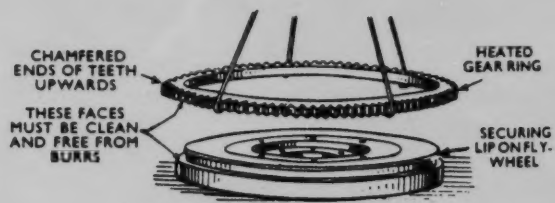
(CAUTION: Do not, under any circumstances, heat the gear over 400°F [204°C]; excessive heat may destroy the original heat treatment and the teeth will be softened.)

(NOTE: Heat indicating "crayons," which are placed on the ring gear and melt at a predetermined temperature, may be obtained from most tool vendors.)

JOB SHEET #12

- G. Use a pair of tongs to place the gear on the flywheel with the chamfer, if any, facing the same direction as on the gear just removed (Figure 1)

FIGURE 1



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- H. Tap the gear in place against the shoulder on the flywheel with a brass drift

CLUTCHES AND FLYWHEELS
UNIT II

NAME _____

TEST

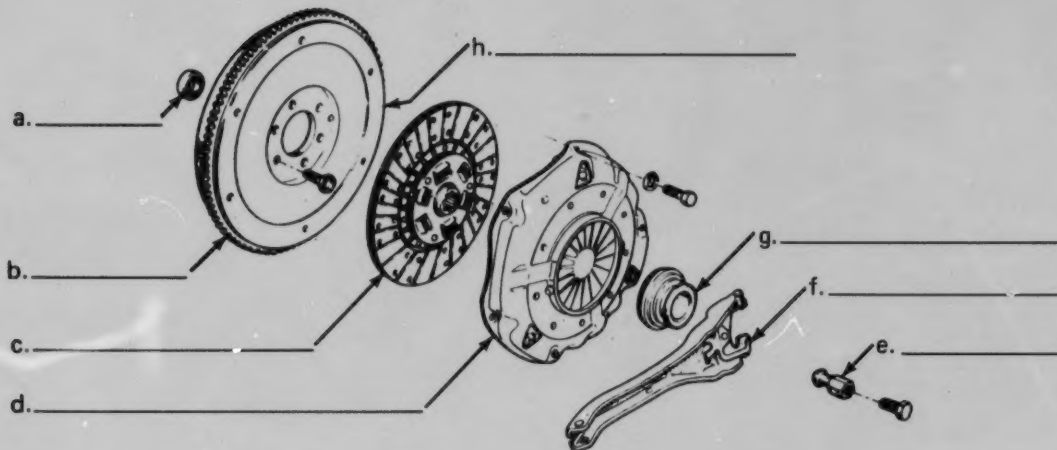
1. Match the terms on the right with their correct definitions.

- | | |
|---|--------------------------|
| _____ a. Heavy metal disc which has a friction surface for clutch plate, supports all of the clutch components, and provides gear teeth on outer rim for starting-motor operation | 1. Slave cylinder |
| _____ b. Bearing located in the flywheel flange of the crankshaft which allows for correct support and alignment of transmission input shaft | 2. Free travel |
| _____ c. Resistance to movement between any two objects placed in contact with each other | 3. Pressure plate |
| _____ d. Provides a friction surface between pressure plate and flywheel, and is splined to fit the transmission input shaft | 4. Clutch housing |
| _____ e. Mounted to the flywheel and supplies the force that holds the clutch plate against the flywheel, causing the flywheel, clutch disc, and pressure plate to rotate as one | 5. Flywheel |
| _____ f. Houses the release levers, springs, and pressure plate | 6. Release fork ball |
| _____ g. Also known as a throw-out bearing; used to activate the release levers or diaphragm | 7. Friction |
| _____ h. Y-shaped lever inside clutch housing used to engage and disengage clutch | 8. Clutch disc spin time |
| _____ i. The distance a clutch pedal must travel from its normal position to the point at which the throw-out bearing engages the release levers | 9. Pilot bearing |
| _____ j. Time it takes for the clutch disc to stop spinning after clutch release | 10. Clutch disc |
| _____ k. Acts as a pivot for release fork | 11. Release fork |
| _____ l. Used on hydraulic clutch system to transmit pressure to the throw-out lever | 12. Clutch cover |

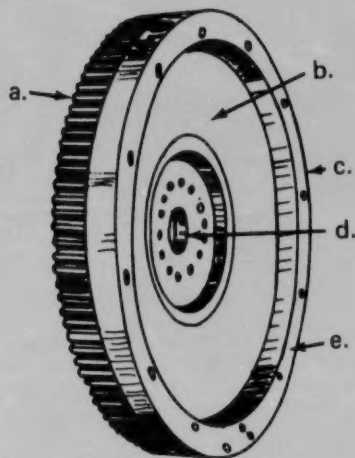
- _____ m. A hydraulic device that forces hydraulic pressure to a slave cylinder to disengage the clutch; it also activates hydraulic brakes
- _____ n. Covers flywheel clutch assembly, provides surface to bolt transmission to engine
- _____ o. A mechanism on the input shaft which helps slow the rotation of the input shaft and the clutch disc to make shifting easier

13. Clutch release bearing
14. Clutch brake
15. Master cylinder

2. Identify the components of the basic clutch assembly in the following illustration.



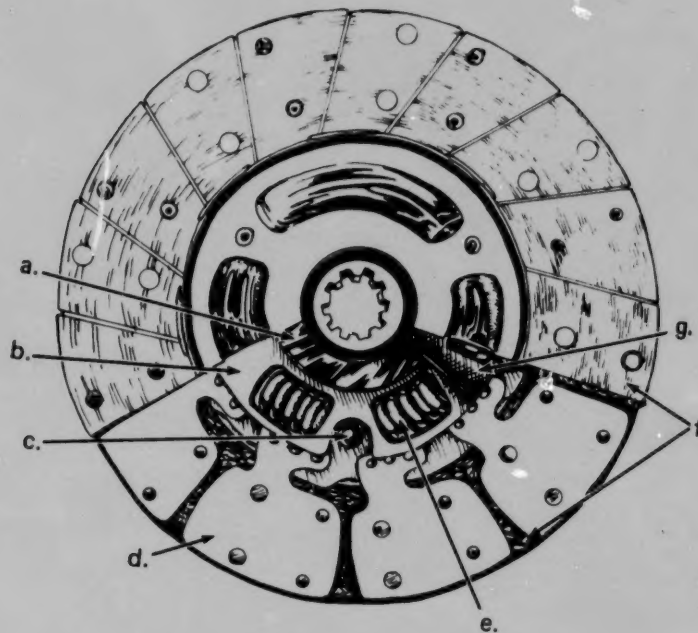
3. Identify the parts of the flywheel in the following illustration.



4. Select from a list the functions of the flywheel by placing an "X" in the correct blanks.

- ☐ a. Supplies power to operate electrical two-speed axle
- ☐ b. Ring gear is mounted around the circumference of flywheel to provide a means for starting
- ☐ c. Operates the push rods for intake and exhaust valves
- ☐ d. Stores up energy during power stroke and delivers energy back during the other strokes
- ☐ e. A flat outer surface is machined smooth to provide a friction surface for the clutch

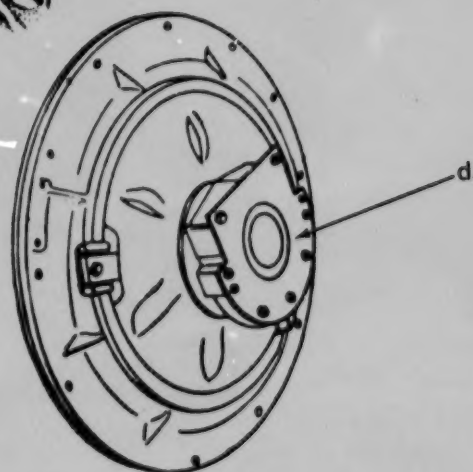
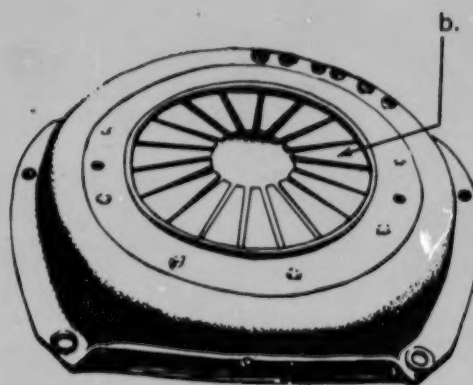
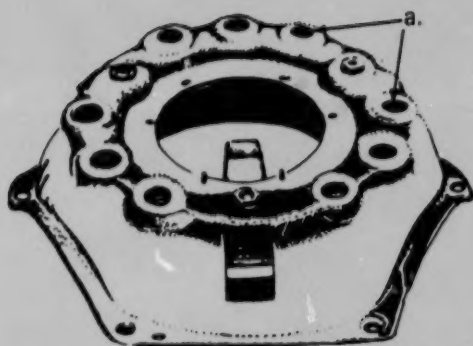
5. Identify the parts of the dry-type disc clutch in the following illustration.



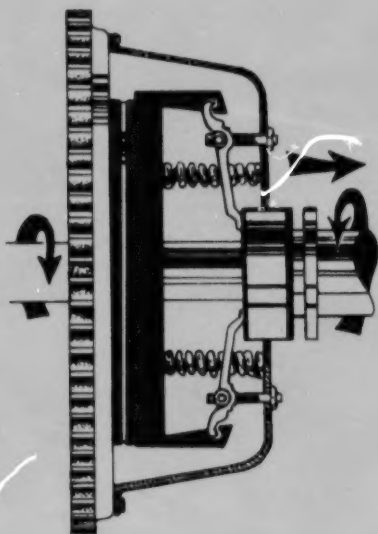
6. Match types of clutches with their descriptions.

- | | |
|--|------------------------|
| _____ a. One or more plates are brought together to transmit torque | 1. Overrunning-type |
| _____ b. An outside band is tightened over a rotating part to transmit torque | 2. Cone-type |
| _____ c. Engagement is allowed in one direction, but the unit freewheels in the other | 3. Disc-type |
| _____ d. A magnetic field holds two parts together, allowing them to rotate as a unit | 4. Band-type |
| _____ e. Two cone-shaped parts are engaged to transmit torque | 5. Expanding-shoe-type |
| _____ f. An inner shoe is expanded to contact an outer part to transmit torque | 6. Magnetic-type |
| _____ g. A pressure plate is forced indirectly over levers and links against the clutch disc; as the clutch is engaged, the levers and links come over the center of the pivot point and lock the engagement | 7. Over center-type |

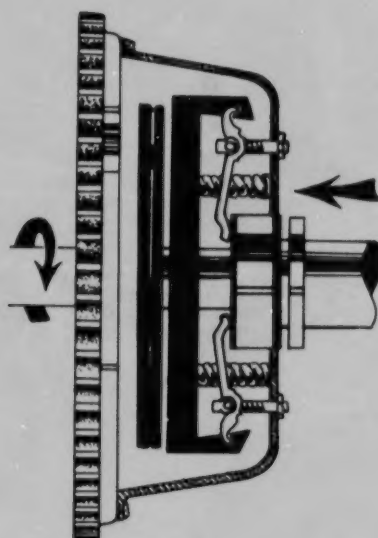
7. Identify the types of pressure plates in the following illustrations.



8. Distinguish between a disengaged and an engaged clutch by writing engaged or disengaged under the appropriate illustration.



a.



b.

9. Match types of clutch linkage mechanisms with their functions.

- | | |
|---|--|
| <p>_____ a. This method uses a series of levers and rods connecting the foot pedal to the throw-out fork</p> <p>_____ b. A master cylinder is connected to, and actuated by, the clutch pedal; the pressure created by depressing the foot pedal is transmitted to the slave cylinder through high pressure hoses; the slave cylinder is mounted near, and connected to, the throw-out lever or fork</p> <p>_____ c. This mechanism uses compressed air and hydraulic assembly supply power for clutch operation on vehicles equipped with a hydraulic clutch cylinder</p> <p>_____ d. Direct-action clutch consists of a field coil assembly, rotor unit, face plate, condenser, and an operating switch; indirect-action clutch consists of a driving member containing a coil, an inner driven member, and a mixture of magnetizable metal and dry lubricant</p> | <p>1. Air operated</p> <p>2. Electrically operated</p> <p>3. Mechanical linkage</p> <p>4. Hydraulic operated</p> |
|---|--|

10. Select from the following list conditions to look for during clutch inspection by placing an "X" in the appropriate blanks.

- ☐ a. Slight chatter marks
- ☐ b. Drive line vibration
- ☐ c. Excessive finger wear
- ☐ d. Incorrect gear select or adjustment
- ☐ e. Incorrect clutch linkage adjustment
- ☐ f. Normal finger wear
- ☐ g. Broken engine motor mounts
- ☐ h. Excessive heat discoloration

11. Select from the following list symptoms that may occur when a clutch housing bore has excessive runout by placing an "X" in the appropriate blanks.

- ☐ a. Broken motor mounts
- ☐ b. Pilot bearing noise
- ☐ c. Rough engine idle
- ☐ d. Starter gear breakage
- ☐ e. Transmission jumping out of gear
- ☐ f. Drive line vibration
- ☐ g. Excessive clutch spin time
- ☐ h. Excessive transmission gear wear or noise

12. Match clutch malfunctions with probable causes.

- | | |
|--|--------------------|
| ☐ a. Water contaminated clutch disc rusted to flywheel and pressure plate | 1. Drag |
| ☐ b. Worn or misaligned linkage; release bearing dragging on support | 2. Grab |
| ☐ c. Uneven pressure plate finger height | 3. Freezing |
| ☐ d. Pressure plate not releasing due to improper linkage adjustment; broken pivots in pressure plate | 4. Pulsating pedal |
| ☐ e. Oil contamination on clutch assembly; broken motor mounts; glazed clutch surface from being overheated | 5. Chatter |

_____ f. Pressure plate spring tension weak; excessively worn clutch disc; oil contamination; improperly adjusted clutch linkage

_____ g. Oil contamination; clutch disc glazed from overheating; warped pressure plate or flywheel; weak pressure plate spring

_____ h. Worn or dry pilot or release bearing when clutch is disengaged; pitted clutch shaft bearing when clutch is engaged with transmission in neutral

6. Binding

7. Bearing noise

8. Slip

13. List three purposes of a dual disc clutch.

- a. _____
- b. _____
- c. _____

14. Demonstrate the ability to:

- a. Adjust clutch linkage free travel.
- b. Adjust free travel on a pull type clutch.
- c. Remove a clutch assembly.
- d. Inspect a clutch disc.
- e. Check a clutch housing alignment.
- f. Inspect a pressure plate and cover.
- g. Inspect a pilot bearing and pilot bushing.
- h. Replace a clutch assembly.
- i. Remove, inspect, repair, and reinstall a 15 1/2-inch dual disc clutch.
- j. Disassemble a hydraulic clutch (wet-type).
- k. Inspect parts of a hydraulic clutch.
- l. Reassemble a hydraulic clutch.
- m. Check flywheel runout.
- n. Remove and replace a flywheel ring gear.
- o. Remove, overhaul, reinstall, and adjust an over center clutch.

(NOTE: If these activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

CLUTCHES AND FLYWHEELS UNIT II

ANSWERS TO TEST

- | | | | | | |
|-------|----|----|----|----|----|
| 1. a. | 5 | f. | 12 | k. | 6 |
| b. | 9 | g. | 13 | l. | 1 |
| c. | 7 | h. | 11 | m. | 15 |
| d. | 10 | i. | 2 | n. | 4 |
| e. | 3 | j. | 8 | o. | 14 |

2.
 - a. Clutch pilot bearing
 - b. Flywheel ring gear
 - c. Clutch disc
 - d. Pressure plate
 - e. Release fork ball
 - f. Clutch release fork
 - g. Clutch release bearing
 - h. Flywheel
3.
 - a. Ring gear
 - b. Flywheel
 - c. Clutch pilot bearing bore
 - d. Flywheel
 - e. Clutch disc contact surface
4. b, d, e
5.
 - a. Friction ring
 - b. Hub flange
 - c. Stop pin
 - d. Cushion springs
 - e. Torsional coil springs
 - f. Facings
 - g. Drive washer
6.

a.	3	e.	2
b.	4	f.	5
c.	1	g.	7
d.	6		
7.
 - a. Coil springs
 - b. Diaphragm spring
 - c. Centrifugal and coil spring
 - d. Pull type
8.
 - a. Engaged
 - b. Disengaged

9. a. 3
b. 4
c. 1
d. 2
10. a, c, f, h
11. b, e, f, g, h
12. a. 3 e. 2
b. 6 f. 8
c. 4 g. 5
d. 1 h. 7
13. Any three of the following:
a. For equipment with heavy loads
b. For engines with high torque and horsepower
c. Allows more friction surface area
d. Doesn't put an excessive load on one clutch disc
e. Allows vehicle to start moving without jerking or jumping
14. Performance skills evaluated to the satisfaction of the instructor

TORQUE CONVERTERS AND FLUID DRIVES UNIT III

UNIT OBJECTIVE

After completion of this unit, the student should be able to identify the parts of a torque converter and discuss the operations of the pump, stator, and turbine in torque converter operation. The student should also be able to drain and refill a torque converter, check for oil leaks, and test a torque converter. This knowledge will be evidenced by correctly performing the procedures outlined in the job sheets and by scoring 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms related to torque converters and fluid drives with their correct definitions.
2. Select true statements concerning how a basic fluid coupling works.
3. Identify the parts of a torque converter.
4. Match torque converter parts with their functions.
5. Match types of fluid flow in torque converters with their characteristics.
6. Complete statements concerning the operation of a twin-turbine torque converter.
7. Select true statements concerning the operation of a lockup clutch converter.
8. Demonstrate the ability to:
 - a. Drain and refill a torque converter.
 - b. Check for oil leaks.
 - c. Test a torque converter.

TORQUE CONVERTERS AND FLUID DRIVES UNIT III

SUGGESTED ACTIVITIES

- I. Provide student with objective sheet.
- II. Provide student with information and job sheets.
- III. Make transparencies.
- IV. Discuss unit and specific objectives.
- V. Discuss information sheet.
- VI. Demonstrate and discuss the procedures outlined in the job sheets.
- VII. Impress upon students that the job sheets in this unit are basically maintenance procedures; checking end play on a torque converter; disassembly, inspection, and rebuilt of a stator assembly; and disassembly and inspection of a torque converter are all presented as job sheets in UNIT V, AUTOMATIC TRANSMISSIONS, so the student will better understand the relation of the torque converter to the transmission and other components in the power train.
- VIII. Invite a guest speaker from industry to come to class and talk to students about torque converters.
- IX. Take a field trip to a company that rebuilds torque converters and automatic transmissions.
- X. Give test.

INSTRUCTIONAL MATERIALS

- I. Included in this unit:
 - A. Objective sheet
 - B. Information sheet
 - C. Transparency masters
 1. TM 1--Operation of a Basic Fluid Coupling
 2. TM 2--Operation of a Basic Fluid Coupling (Continued)
 3. TM 3--Parts of a Fluid Coupling
 4. TM 4--Parts of a Torque Converter
 5. TM 5--One-way Roller Clutch and Stator Assembly

- 6. TM 6--Fluid Flow
- 7. TM 7--Twin Turbine
- 8. TM 8--Lockup Mechanism
- D. Job sheets
 - 1. Job Sheet #1--Drain and Refill a Torque Converter
 - 2. Job Sheet #2--Check for Oil Leaks
 - 3. Job Sheet #3--Test a Torque Converter
- E. Test
- F. Answers to test

II. References:

- A. Stockel, Martin W. *Auto Service and Repair*. South Holland, IL: The Goodheart-Wilcox Co., Inc., 1969.
- B. Notgrass, Troy. *The Automotive Power Train Mechanic*. Austin, TX: Instructional Materials Service Division of Extension, The University of Texas at Austin, 1973.
- C. *1968 Ford Truck Shop Manual*. Dearborn, MI: Ford Service Publications, 1968.
- D. Forier, Louis C. *Motor Trucks and Diesel Repair Manual*. 33rd Edition. New York, NY 10010: Motor, 1980.
- E. *Fundamentals of Service: Power Trains*. Moline, IL 61265: John Deere Service Publications, Dept. F, 1972.
- F. *Hydra-matic THM200 Principles of Operation*. Ypsilanti, MI 48197: General Motors Corporation, 1975.
- G. *Allison Transmissions Service Manual*. Indianapolis, IN 46206: Detroit Diesel Allison, 1979.
- H. *1980 Light Duty Truck Chassis Service Manual*. Detroit, MI: General Motors Corporation, 1979.
- I. Dallas Independent School District. *Diesel Technology Student Learning Plan*. New York, NY: Harper and Row, Publishers, Inc., 1975.

TORQUE CONVERTERS AND FLUID DRIVES UNIT III

INFORMATION SHEET

- I. Terms and definitions
 - A. Torque converter--Serves as a fluid coupling to smoothly connect engine power through oil to the transmission gear train and multiplies the torque effort from engine
 - B. Fluid drive--A pair of vaned rotating elements held in position close to each other without touching; rotation is transferred to the driven member by this driving member through the resistance of a body of oil
 - C. Turbine--A wheel upon which a series of angled vanes are affixed so that a moving column of liquid will impart a turning motion
 - D. Stator--In a torque converter, the third member which redirects fluid direction under certain operating conditions
 - E. Pump--A device which produces motion in a liquid, in a torque converter it is the driving member
 - F. Hydraulic--Refers to fluids in motion and the science of fluids in motion
 - G. Transmission stall test--A test made while the output shaft is braked and the engine is running at full throttle; the recorded engine speed is then compared with normal speed from an engine-converter chart to see whether or not the engine, torque converter, and transmission are performing satisfactorily as a unit
 - H. Torque multiplication--Increased pump speed and oil flow restricted by stator which puts a twisting force on turbine
 - I. Fluid coupling--A unit that transfers engine torque to the transmission input shaft through the use of two vaned units operating very close together in a bath of oil
 - J. Velocity--The rate of motion or speed at which something (fluid for instance) moves
- II. How a basic fluid coupling works (Transparencies 1, 2, and 3)
 - A. A fluid at high velocity strikes a turbine and forces it to turn, driving the wheel
(NOTE: Torque is transmitted by a fluid.)
 - B. Placing two fans facing each other and turning one fan will cause the other fan to turn
(NOTE: This principle is used in a fluid coupling.)
 - C. When fluid is not in motion it lies level in a bowl

INFORMATION SHEET

- D. When the bowl is spun rapidly, centrifugal force causes the fluid to climb up and over the outside edge of the bowl
- E. When another bowl is placed down over the first one, and when the bowls are spun, an axial flow is created and turning force is transmitted between the driving bowl and the driven bowl

III. Parts of a torque converter (Transparency 4)

- A. Pump (driving member)
- B. Turbine (driven member)
- C. Stator (reaction member)

IV. Torque converter parts and their functions (Transparency 4)

A. Pump (impeller)

1. The converter cover is secured to pump to seal all three members in an oil filled housing
(NOTE: Torque converter part names vary with type and manufacturer.)
2. Converter cover is bolted to the flexplate which is bolted to the engine crankshaft
3. The converter pump turns the same speed as engine
4. When engine is running the pump is spinning; it acts as a centrifugal pump
5. The pump picks the oil up at the pump's center and discharges the oil at its rim between the blades
6. The blades cause the oil to leave pump spinning toward the blades of the turbine

B. Turbine (Transparency 4)

1. Turbine is connected to the input shaft of transmission
2. When oil from the pump strikes the turbine blades, it transfers a force to the turbine causing it to turn
3. When the engine is idling and converter pump is not spinning fast, the force of the oil leaving pump is not great enough to turn the turbine with any efficiency
4. As engine speeds up, the pump speed increases, and the force of oil is greater to turn turbine

INFORMATION SHEET

C. Stator

1. The stator is located between the pump and turbine
2. It is mounted on a one-way roller clutch which allows it to rotate one way but not the other (Transparency 5)
3. It redirects the oil from turbine and changes its direction of rotation back to that of the pump member
4. The energy of the oil is then used to assist the engine in turning pump
5. This increases the force of the oil driving the turbine, and as a result this multiplies the torque or twisting force

V. Types of fluid flow in torque converters and their characteristics

- A. Rotary flow--The instant the torque converter impeller (pump), which is driven by the engine flywheel, starts rotating, the oil spins around with it (Transparency 6)
- B. Vortex flow--The converter turbine, connected to the input shaft, resists turning as the oil strikes its blades; because of this resistance and because of the shape of the blades, the oil takes a second path of travel crosswise (Transparency 6)
- C. Kinetic energy--The more oil entering the pump from the stator, and the more the turbine resists turning, the greater the velocity of the vortex flow of oil circulating in the converter and the greater the torque multiplication

VI. Operation of a twin-turbine torque converter (Transparency 7)

- A. When torque demand is high, the freewheel clutch is engaged and the first turbine, assisted by the second turbine, drives the gears

(NOTE: The first turbine provides high torque and low speed for starting up and loading.)

- B. When the machine speeds up, torque demand drops, and the second turbine takes over the entire load and the freewheel clutch disengages the first turbine

(NOTE: The second turbine provides higher speed with lower torque for travel.)

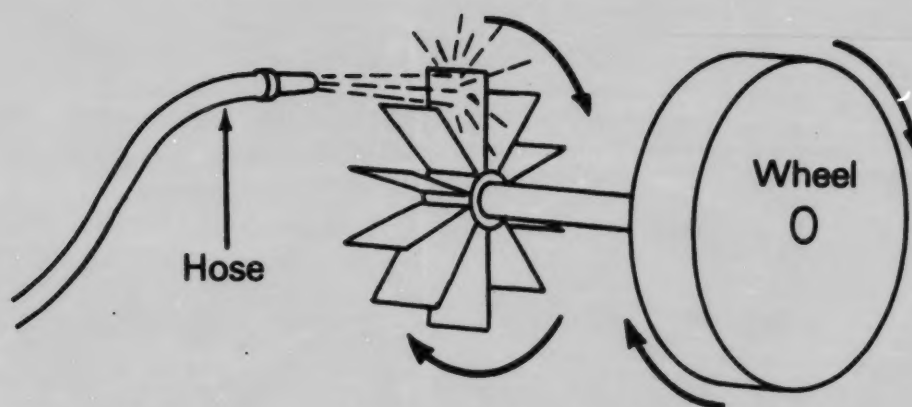
VII. Operation of a lockup clutch converter (Transparency 8)

- A. Located inside of torque converter housing
- B. It operates at higher speeds and higher gear range

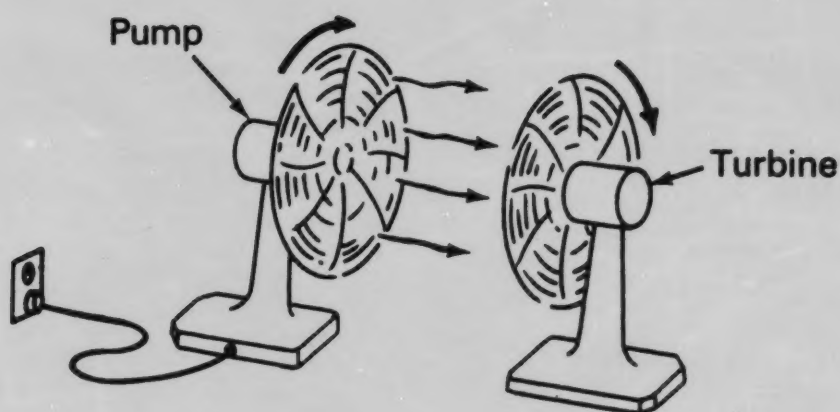
INFORMATION SHEET

- C. When the lockup clutch is applied, the converter elements (pump, turbine, and stator) rotate as a unit at engine speed
- D. This provides a direct drive from the engine to the turbine shaft
- E. When the lockup clutch is applied, slippage is eliminated

Operation of a Basic Fluid Coupling



Fluids at high velocities can transmit power.

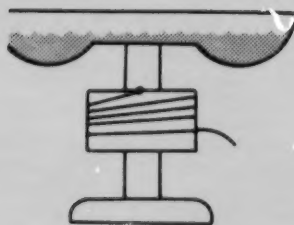


One part can drive another part by force of air or oil.

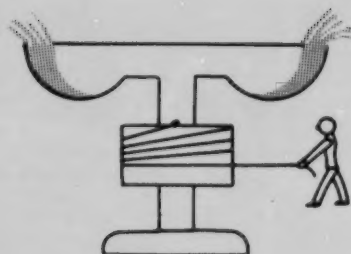
Courtesy DEERE & CO., MOLINE, IL

Operation of a Basic Fluid Coupling

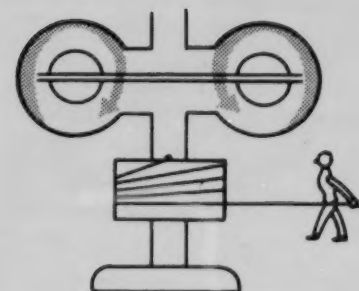
(Continued)



Fluid lies
level in bowl.



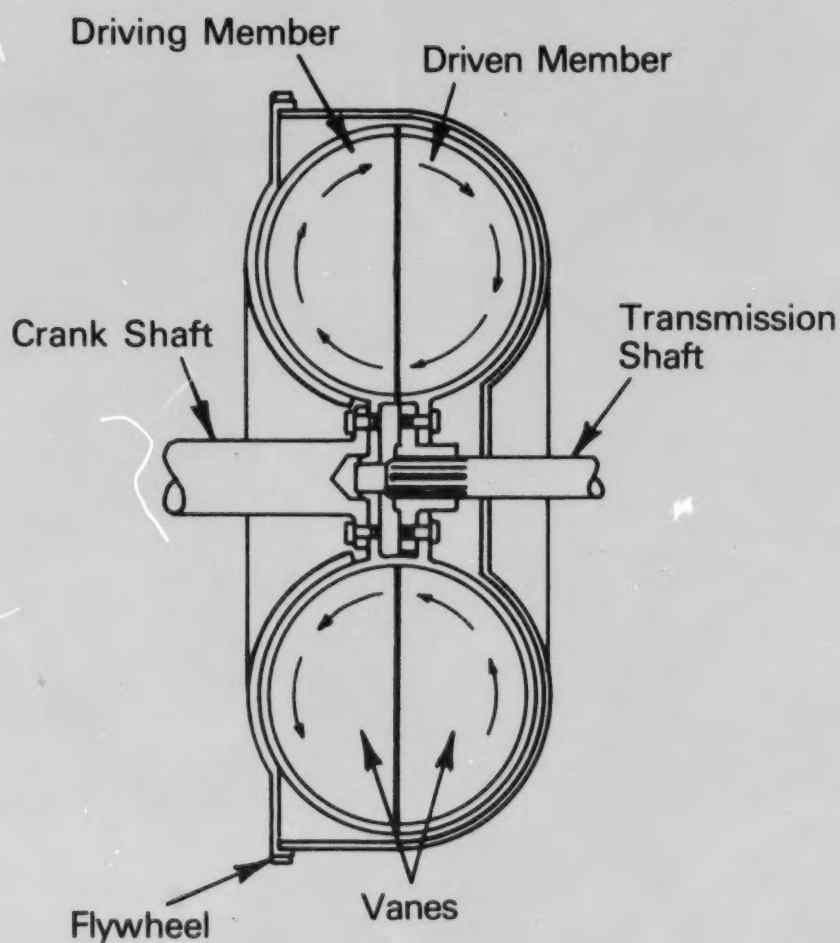
Bowl is spun
and fluid
spills out.



Torque is
transmitted to
upper bowl by
force of fluid.

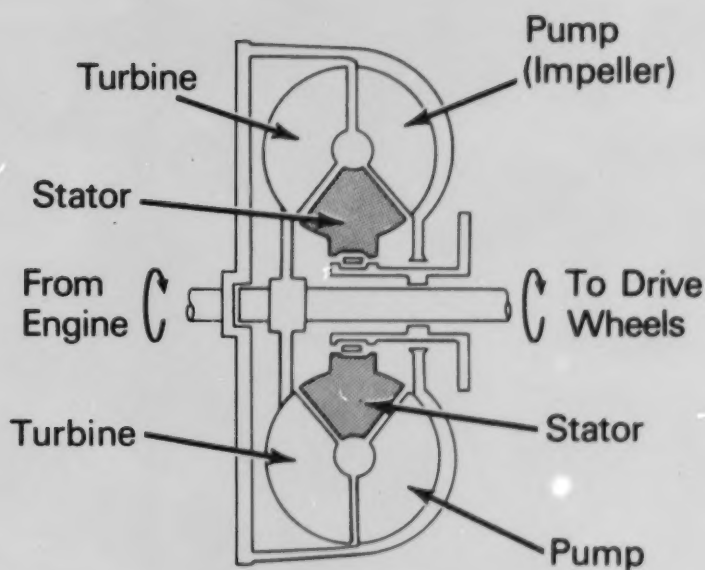
Courtesy DEERE & CO., MOLINE, IL

Parts of a Fluid Coupling

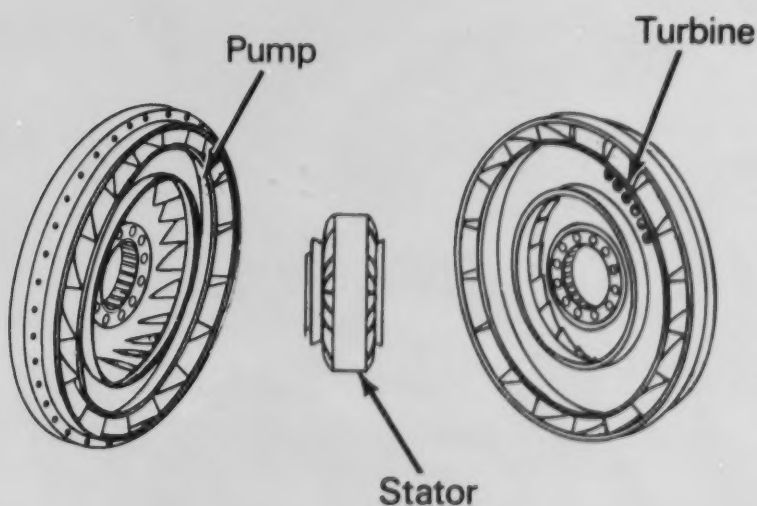


One member of the coupling is mounted on the driving shaft and the other member is mounted to the transmission shaft.

Parts of a Torque Converter

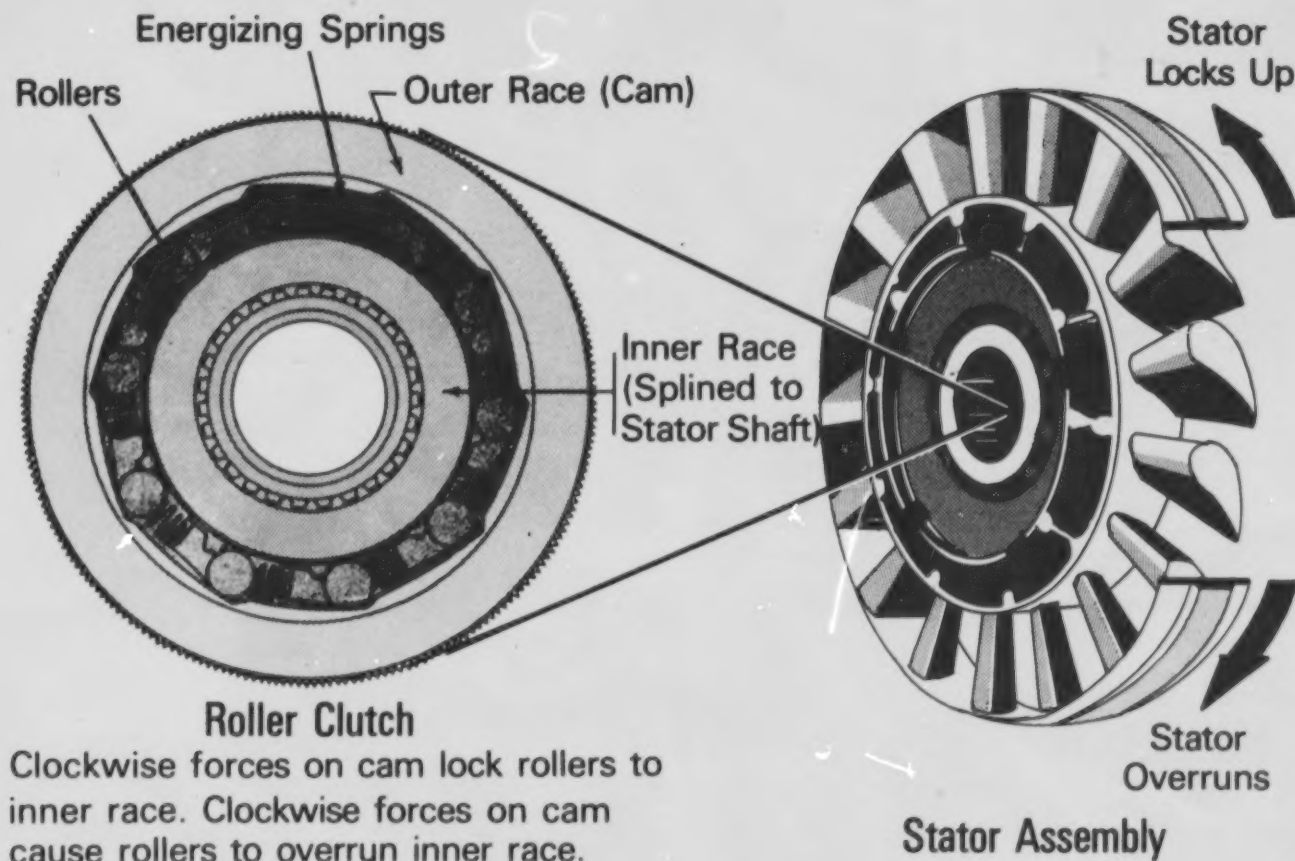


Courtesy DEERE & CO., MOLINE, IL

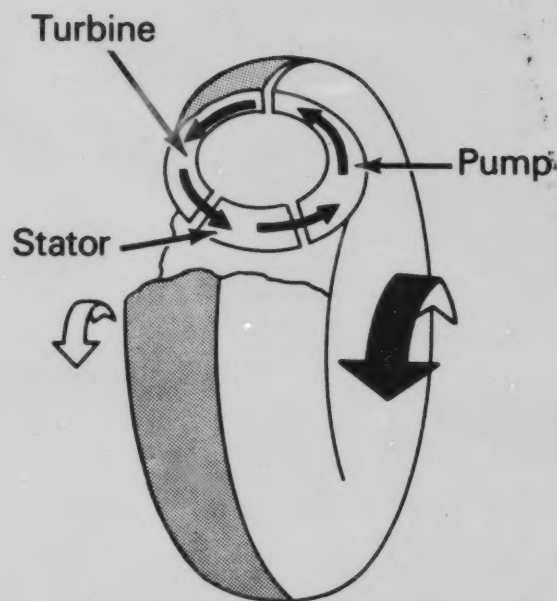


Courtesy General Motors Corporation

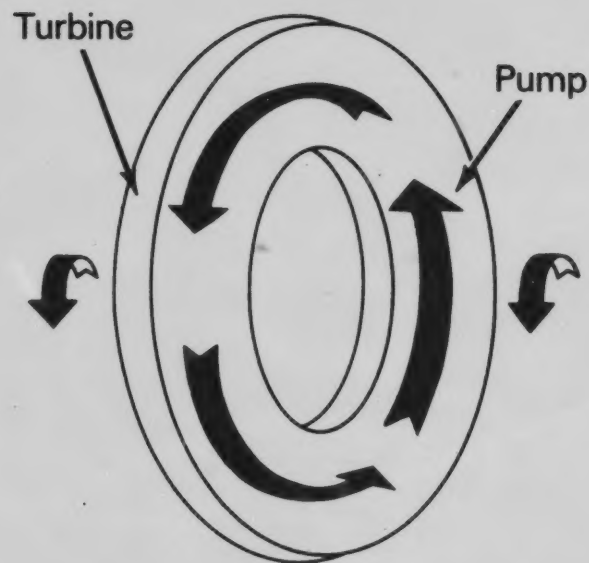
One-Way Roller Clutch and Stator Assembly



Fluid Flow

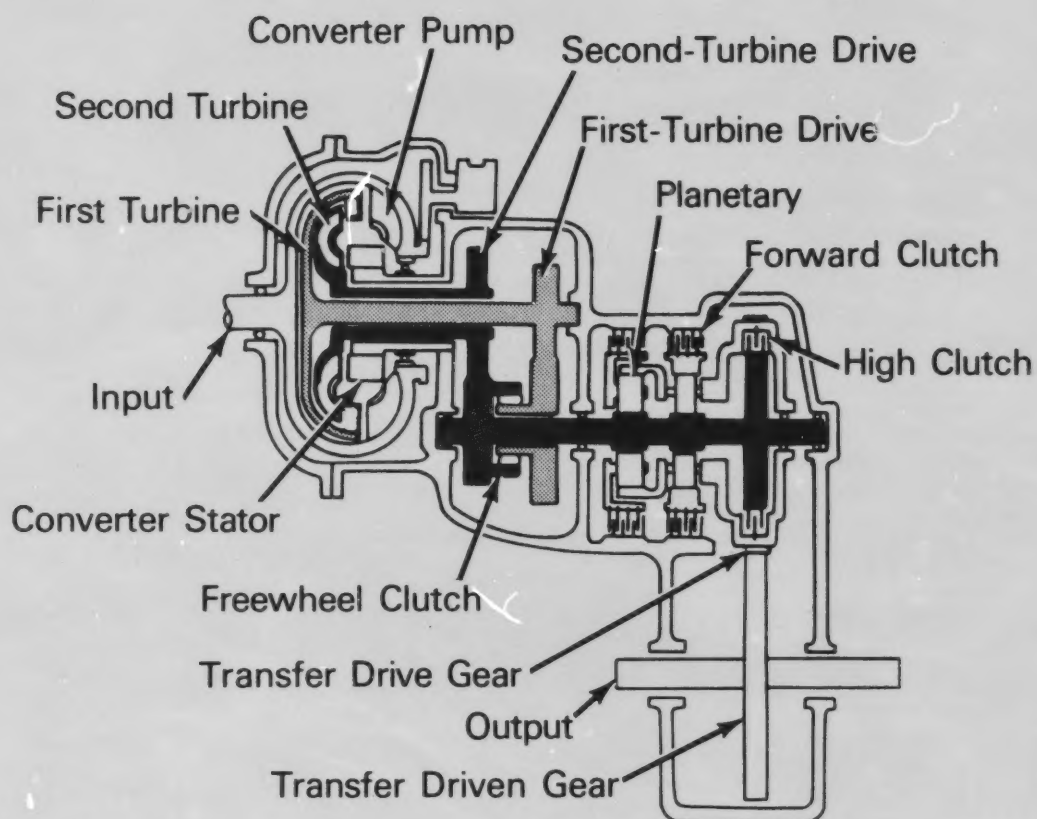


While torque is increasing—
more vortex flow—
pump is turning faster.



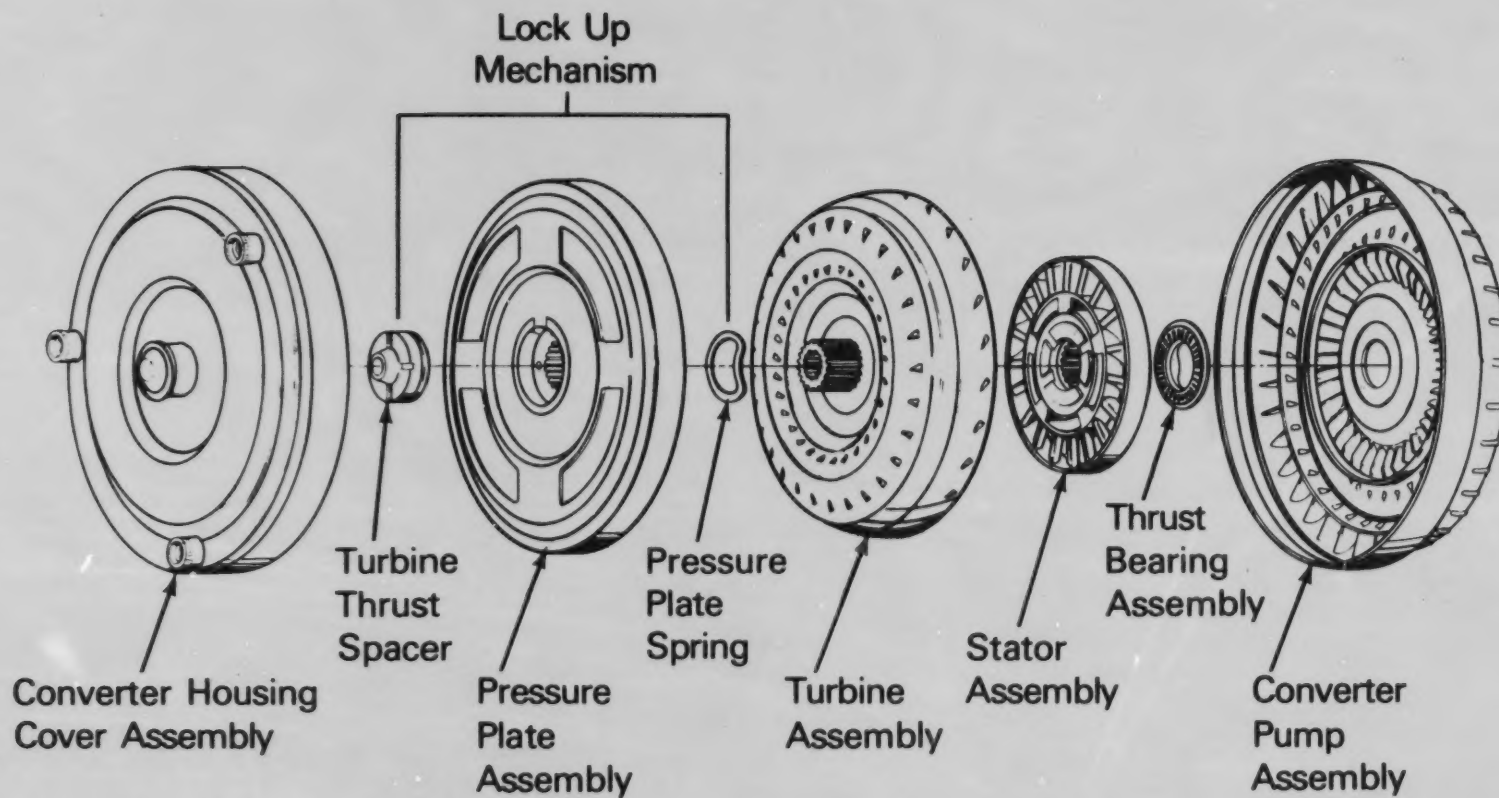
While torque is decreasing—
more rotary flow—
pump and turbine
reach same speed.

Twin Turbine



Courtesy DEERE & CO., MOLINE, IL

Lockup Mechanism



TORQUE CONVERTERS AND FLUID DRIVES UNIT III

JOB SHEET #1-DRAIN AND REFILL A TORQUE CONVERTER

I. Tools and materials

- A. Basic hand tools
- B. Drop light
- C. Drain pan
- D. Funnel
- E. Creeper
- F. Shop towels
- G. Safety glasses

II. Procedure

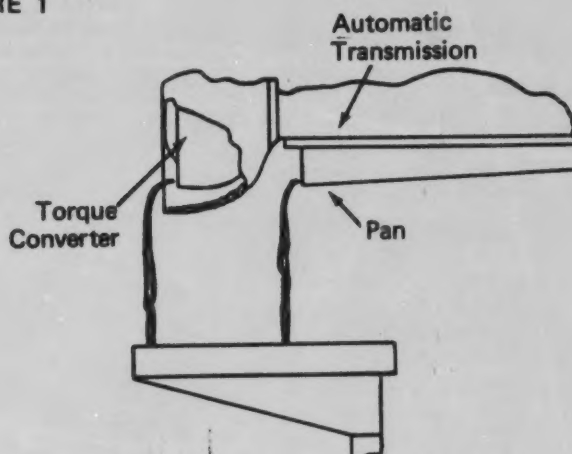
- A. Make sure fluid is at normal operating temperature to insure proper drainage

(CAUTION: Be careful when draining as the fluid may be hot enough to produce serious burns.)

- B. Remove the converter drain plug (Figure 1)

(NOTE: Some transmissions require draining both the converter and oil pan; some require draining the oil pan [case] only.)

FIGURE 1



JOB SHEET #1

- C. Install the converter drain plug and torque as specified

(NOTE: Converter plugs are made of relatively soft material and should not be overtightened.)

- D. Add the required amount of new fluid BEFORE starting engine

(NOTE: Fill with manufacturer's specification oil.)

- E. Start engine, move shift lever through all drive ranges, and return to park

(NOTE: Be sure to shift lever in all ranges to insure fluid to all valves and clutches.)

- F. Idle engine to heat up fluid, and check level when hot

- G. Add more fluid if needed, but DO NOT OVERFILL

**TORQUE CONVERTERS AND FLUID DRIVES
UNIT III**

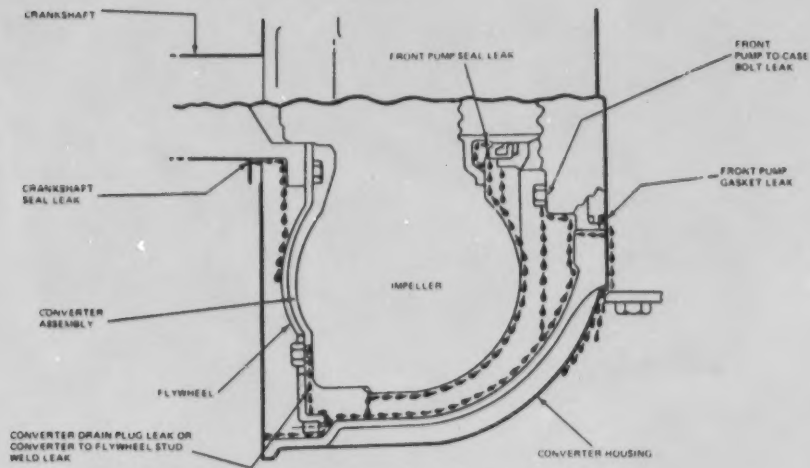
JOB SHEET #2-CHECK FOR OIL LEAKS

- I. Tools and materials
 - A. Basic hand tools
 - B. Shop towels
 - C. Drop light
 - D. Creeper
 - E. Jack, blocks, and safety stands
 - F. Safety glasses
- II. Procedure
 - A. Jack vehicle and block up for safe inspection
 - B. Remove the converter housing inspection pan and clean the converter
 - C. Clean inside of housing and blow dry
 - D. Run engine at fast idle to bring the transmission fluid to normal operating temperature
 - E. Shift transmission through all drive ranges to force fluid through all lines
 - F. Watch carefully for the first sign of a fluid leak

JOB SHEET #2

G. Determine if fluid is coming from transmission or from engine (Figure 1)

FIGURE 1



Courtesy Ford Motor Company

(NOTE: Converter leaks, other than a leaking drain, as well as front seal leak, usually require transmission removal.)

TORQUE CONVERTERS AND FLUID DRIVES
UNIT III

JOB SHEET #3--TEST A TORQUE CONVERTER

I. Tools and materials

- A. Basic hand tools
- B. Shop towels
- C. Wooden block
- D. Safety glasses

II. Procedure

- A. Block vehicle
- B. Check the fluid level in transmission
- C. Start the engine and warm the engine and transmission to operating temperature
- D. Shift transmission shift lever into each gear range

(NOTE: Never allow the transmission to heat up beyond the maximum operating temperature.)

- E. Attach the necessary temperature and pressure gauges to the converter
- F. Check with service manual for these tests on the torque converter:
 - 1. Main pressure (at full throttle--no load)
 - 2. Converter-out pressure
 - 3. Converter-in pressure, if required
 - 4. Lubrication pressure
 - 5. Converter-out temperature
- G. Perform a transmission stall test

(NOTE: Be sure to check service manual on type of transmission before conducting stall test. Some manufacturers do not recommend this test.)

- H. Brake the output shaft and run the engine at full throttle while conducting the stall test

TORQUE CONVERTERS AND FLUID DRIVES UNIT III

NAME _____

TEST

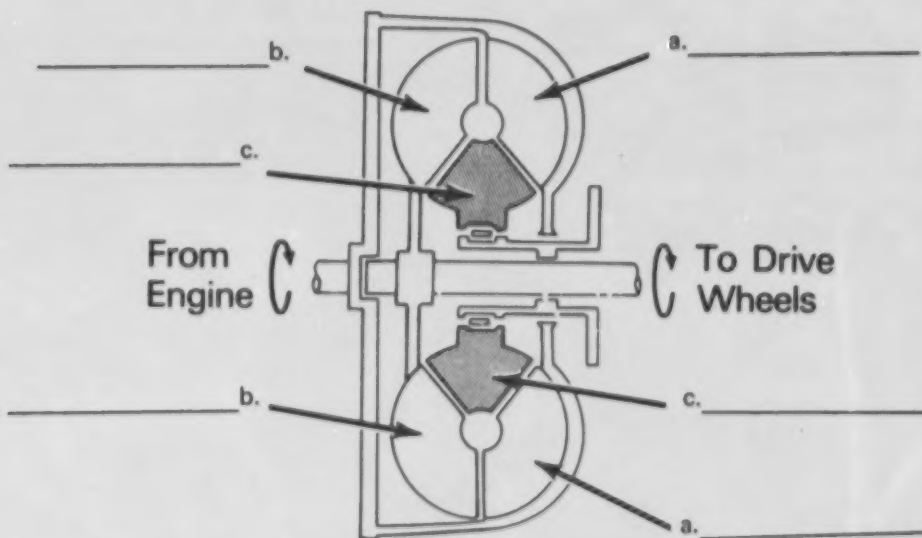
1. Match the terms on the right with their correct definitions.

- | | |
|--|----------------------------|
| _____ a. Serves as a fluid coupling to smoothly connect engine power through oil to the transmission gear train and multiplies the torque effort from engine | 1. Hydraulic |
| _____ b. A pair of vaned rotating elements held in position close to each other without touching; rotation is transferred to the driven member by this driving member through the resistance of a body of oil | 2. Velocity |
| _____ c. A wheel upon which a series of angled vanes are affixed so that a moving column of liquid will impart a turning motion | 3. Transmission stall test |
| _____ d. In a torque converter, the third member which redirects fluid direction under certain operating conditions | 4. Pump |
| _____ e. A device which produces motion in a liquid, in a torque converter it is the driving member | 5. Torque multiplication |
| _____ f. Refers to fluids in motion and the science of fluids in motion | 6. Turbine |
| _____ g. A test made while the output shaft is braked and the engine is running at full throttle; the recorded engine speed is then compared with normal speed from an engine-converter chart to see whether or not the engine, torque converter, and transmission are performing satisfactorily as a unit | 7. Fluid coupling |
| _____ h. Increased pump speed and oil flow restricted by stator which puts a twisting force on turbine | 8. Torque converter |
| _____ i. A unit that transfers engine torque to the transmission input shaft through the use of two vaned units operating very close together in a bath of oil | 9. Stator |
| _____ j. The rate of motion or speed at which something moves | 10. Fluid drive |

2. Select true statements concerning how a basic fluid coupling works by placing an "X" in the appropriate blanks.

- _____ a. When fluid is not in motion it lies level in a bowl
- _____ b. Placing two fans facing each other and turning one fan on will cause the other fan to turn
- _____ c. When a fluid in a bowl is spun the fluid tries to come out the center of bowl
- _____ d. A fluid at high velocity strikes a turbine and forces it to turn, driving the wheel
- _____ e. The converter pump is driven by the turbine
- _____ f. When another bowl is placed down over the first one, and when the bowls are spun an axial flow is created and turning force is transmitted between the driving bowl and the driven bowl
- _____ g. When the bowl is spun rapidly, centrifugal force causes the fluid to climb up and over the outside edge of the bowl

3. Identify the parts of a torque converter by writing correct answers in blanks provided.



4. Match torque converter parts on the right with their functions.

- | | |
|--|---|
| <p>_____ a. The converter cover is secured to pump to seal all three members in an oil filled housing; converter cover is bolted to the flexplate which is bolted to the engine crankshaft; the converter pump turns the same speed as engine; when engine is running the pump is spinning; it acts as a centrifugal pump; the pump picks the oil up at the pump's center and discharges the oil at its rim between the blades; the blades cause the oil to leave pump spinning toward the blades of the turbine</p> <p>_____ b. This device is connected to the input shaft of transmission; when oil from the pump strikes the turbine blades, it transfers a force to the turbine causing it to turn; when the engine is idling and converter pump is not spinning fast, the force of the oil leaving pump is not great enough to turn the turbine with any efficiency; as engine speeds up, the pump speed increases, and the force of oil is greater to turn turbine</p> <p>_____ c. This device is located between the pump and turbine; it is mounted on a one-way roller clutch which allows it to rotate one way but not the other; it redirects the oil from turbine and changes its direction of rotation back to that of the pump member; the energy of the oil is then used to assist the engine in turning pump; this increases the force of the oil driving the turbine, and as a result this multiplies the torque or twisting force</p> | <p>1. Stator</p> <p>2. Pump</p> <p>3. Turbine</p> |
|--|---|

5. Match the types of fluid flow in torque converters on the right with their characteristics.

- | | |
|---|--|
| <p>_____ a. The instant the torque converter impeller (pump), which is driven by the engine fly-wheel, starts rotating, the oil spins around with it</p> <p>_____ b. The converter turbine, connected to the input shaft, resists turning as the oil strikes its blades; because of this resistance and because of the shape of the blades, the oil takes a second path of travel crosswise</p> | <p>1. Vortex flow</p> <p>2. Kinetic energy</p> <p>3. Rotary flow</p> |
|---|--|

- _____ c. The more oil entering the pump from the stator, and the more the turbine resists turning, the greater the velocity of the vortex flow of oil circulating in the converter and the greater the torque multiplication
6. Complete the following statements concerning operation of a twin-turbine torque converter.
- When torque demand is high, the freewheel clutch is engaged and the _____ turbine, assisted by the _____ turbine, drives the gears
 - When the machine speeds up, torque demand drops, and the _____ turbine takes over the entire load and the freewheel clutch disengages the _____ turbine
7. Select true statements concerning operation of a lockup clutch converter by placing an "X" in the appropriate blanks.
- _____ a. When the lockup clutch is applied, slippage is eliminated
 - _____ b. This provides a direct drive from the engine to the turbine shaft
 - _____ c. Located inside of torque converter housing
 - _____ d. Lockup clutches are engaged at all times except in high gear
 - _____ e. When the lockup clutch is applied, the converter elements rotate as a unit at engine speed
 - _____ f. It operates at higher speeds and in higher gear range
8. Demonstrate the ability to:
- Drain and refill a torque converter.
 - Check for oil leaks.
 - Test a torque converter.

(NOTE: If these activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

TORQUE CONVERTERS AND FLUID DRIVES UNIT III

ANSWERS TO TEST

- | | |
|---------|------|
| 1. a. 8 | f. 1 |
| b. 10 | g. 3 |
| c. 6 | h. 5 |
| d. 9 | i. 7 |
| e. 4 | j. 2 |
2. a, b, d, f, g
3. a. Pump
 b. Turbine
 c. Stator
4. a. 2
 b. 3
 c. 1
5. a. 3
 b. 1
 c. 2
6. a. First
 Second

 b. Second
 First
7. a, b, c, e, f
8. Performance skills evaluated to the satisfaction of the instructor

MECHANICAL TRANSMISSIONS UNIT IV

UNIT OBJECTIVE

After completion of this unit, the student should be able to identify types of mechanical transmissions and the shafts, housings, and shift control components of mechanical transmissions. The student should also be able to indicate air flow in range shifting lines, disassemble and reassemble a mechanical transmission, and complete related troubleshooting activities. This knowledge will be evidenced by correctly performing the procedures outlined in the assignment and job sheets and by scoring 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms related to mechanical transmissions with their correct definitions.
2. Identify types of mechanical transmissions.
3. Identify parts of a sliding gear transmission.
4. Identify parts of a sliding clutch transmission top shaft.
5. Complete a list of parts on a front section countershaft.
6. Identify parts of a transmission front section case with clutch housing.
7. Identify parts of an auxiliary section of a ten speed transmission.
8. Identify parts of a shift lever housing and reverse stop plunger.
9. Identify parts of a shift bar housing.
10. Identify parts of a remote shift control assembly.
11. Select true statements concerning air flow for range shifting.
12. Indicate air flow in air lines for range shifting.
13. Demonstrate the ability to:
 - a. Check a mechanical transmission fluid level.
 - b. Remove and disassemble a mechanical transmission.
 - c. Inspect transmission parts.

- d. Reassemble a mechanical transmission.
- e. Dissassemble a shifting bar housing.
- f. Inspect a shifting bar housing and parts.
- g. Reassemble a shifting bar housing.
- h. Install a mechanical transmission.
- i. Test a mechanical transmission after rebuilding.

MECHANICAL TRANSMISSIONS UNIT IV

SUGGESTED ACTIVITIES

- I. Provide student with objective sheet.
- II. Provide student with information, assignment, and job sheets.
- III. Make transparencies.
- IV. Discuss unit and specific objectives.
- V. Discuss information and assignment sheets.
- VI. Demonstrate and discuss the procedures outlined in the job sheets.
- VII. Show slides and films on mechanical transmissions.
- VIII. Have speaker from local company that works on transmissions talk to the class.
- IX. Show examples of different types of mechanical transmissions.
- X. Give test.

INSTRUCTIONAL MATERIALS

- I. Included in this unit:
 - A. Objective sheet
 - B. Information sheet
 - C. Transparency masters
 1. TM 1--Sliding Gear Transmission with Shafts in Line
 2. TM 2--Sliding Clutch Transmission
 3. TM 3--Synchromesh Transmission
 4. TM 4--Marine Gear Transmission
 5. TM 5--Parts of Sliding Clutch Transmission Top Shaft Assembly
 6. TM 6--Parts of Front Section Countershaft
 7. TM 7--Transmission Front Section Case with Clutch Housing
 8. TM 8--Parts of Auxiliary Section, Ten Speed Transmission
 9. TM 9--Parts of Shift Lever Housing and Reverse Stop Plunger

10. TM 10--Parts of a Shift Bar Housing
11. TM 11--Remote Shift Control Assembly
12. TM 12--Airflow For Range Shifting
13. TM 13--Air Flow For Range Shifting (Continued)
- D. Assignment Sheet #1--Indicate Air Flow in Air Lines for Range Shifting
- E. Answers to assignment sheet
- F. Job Sheets
 1. Job Sheet #1--Check a Mechanical Transmission Fluid Level
 2. Job Sheet #2--Remove and Disassemble a Mechanical Transmission
 3. Job Sheet #3--Inspect Transmission Parts
 4. Job Sheet #4--Reassemble a Mechanical Transmission
 5. Job Sheet #5--Disassemble a Shifting Bar Housing
 6. Job Sheet #6--Inspect a Shifting Bar Housing and Parts
 7. Job Sheet #7--Reassemble a Shifting Bar Housing
 8. Job Sheet #8--Install a Mechanical Transmission
 9. Job Sheet #9--Test a Mechanical Transmission After Rebuilding
- G. Test
- H. Answers to test

II. References:

- A. *Truck Talk*. Chicago, IL 60611: International Harvester Co., 1977.
- B. *Spicer 1107 Series, 7-Speed Transmission Service Manual*. Toledo, OH 43696: Dana Corporation, 1978.
- C. *Fundamentals of Service: Power Trains*. Moline, IL 61265: John Deere Service Publications, Dept. F, 1972.
- D. *Service Manual-RT 610 Series*. Kalamazoo, MI 49007: Eaton Corporation, Transmission Division, 1973.
- E. *Service Manual-RT 613 Series*. Kalamazoo, MI 49007: Eaton Corporation, Transmission Division, 1972.
- F. *Service Manual-3992 Marine Gears*. Peoria, IL: Caterpillar Tractor Co.
- G. Ivan J. Armstrong. *Auto Mechanics: Volume I*. Stillwater, OK 74074: State Department of Vocational and Technical Education, 1976.

MECHANICAL TRANSMISSIONS
UNIT IV

INFORMATION SHEET

I. Terms and definitions

- A. Transmission--Used to multiply engine torque and vary vehicle speed by means of gears arranged so that different ratios can be selected to meet various operating requirements
- B. Spur gears--Gears with straight teeth
(NOTE: Spur gears are usually used in sliding gear mechanical transmissions.)
- C. Helical gears--Gears with slanted teeth; usually found in constant mesh synchronized transmissions
(NOTE: The teeth are positioned diagonally across the face of the gear.)
- D. Overdrive transmission--A transmission in which the gear ratio is less than one to one
(NOTE: This permits the vehicle, under favorable conditions, to maintain a higher road speed with any given engine speed or a given road speed at a lower engine R.P.M.)
- E. Gear ratio--The number of revolutions the driving gear must make to turn the driven gear one revolution
- F. Synchronizer--Device in the transmission that allows two gears being shifted together to rotate at the same speed
- G. Idler gear--Gear in the transmission used to change direction of rotation of the output shaft
- H. Gear timing--Timing assures that the countershaft gears will contact the mating mainshaft gears at the same time, allowing mainshaft gears to center on the mainshaft and equally divide the load
- I. Countershaft--An intermediate shaft which receives motion from a main shaft and transmits it to a working part
- J. Gear--A cylinder or cone-shaped part having teeth on one surface which mate with and engage the teeth of another part which is not concentric with it
- K. Input shaft--The shaft carrying the driving gear by which the power is applied to the transmission
- L. Output shaft--The shaft or gear which delivers the power from a device (transmission) to the rest of the power train

INFORMATION SHEET

- II. Types of mechanical transmissions
 - A. Sliding gear (Transparency 1)
 - B. Sliding clutch (Transparency 2)
 - C. Synchromesh (Transparency 3)
 - D. Marine gear (Transparency 4)
- III. Parts of a sliding gear transmission (Transparency 1)
 - A. First speed gear on input shaft
 - B. Second speed gear on input
 - C. Third speed gear on input shaft
 - D. First, reverse sliding gear
 - E. Second, third sliding gear
 - F. Third speed gear on output shaft
 - G. Reverse idler output gear
 - H. Reverse idler input gear
 - I. Idler shaft
 - J. Input shaft
 - K. Output shaft
- IV. Parts of a sliding clutch transmission top shaft (Transparency 5)
 - A. Snap ring
 - B. Drive gear bearing
 - C. Spacer
 - D. Gear snap ring
 - E. Clutch shaft
 - F. Drive gear
 - G. Sliding clutch
 - H. Washer
 - I. 4th speed gear
 - J. 3rd speed gear

INFORMATION SHEET

- K. 2nd speed gear
 - L. 1st speed gear
 - M. Reverse gear
 - N. Mainshaft
 - O. Key
 - P. Bearing
 - Q. Auxiliary drive gear
- V. Parts on a front section countershaft (Transparency 6)
- (NOTE: The RT610 transmission uses two countershafts.)
- A. Woodruff key
 - B. Roll pin
 - C. Gear key
 - D. Snap ring
 - E. PTO and 2nd speed gear cluster
 - F. 3rd speed gear
 - G. 4th speed gear
 - H. Drive gear
- VI. Parts of a transmission front section case with clutch housing (Transparency 7)
- A. Clutch housing
 - B. Clutch cross shaft bushings
 - C. Inspection plate
 - D. PTO cover plate gasket
 - E. Front gasket
 - F. PTO cover plate
 - G. Lube filler plug
 - H. Oil temperature plug
 - I. Lubeoil drain plug
 - J. Oil sleeves

INFORMATION SHEET

- K. Rear gasket
- L. Dowel pin
- M. Magnetic discs (2)
- N. Front section case
- VII. Parts of an auxiliary section of a ten speed transmission (Transparency 8)
 - A. Countershaft front bearings (2)
 - B. Pilot bearing
 - C. Auxiliary countershaft assemblies (2)
 - D. Synchronizer assemblies
 - E. Low speed gear and tailshaft assembly
 - F. Auxiliary housing and rear bearing assembly
 - G. Countershaft bearing (2)
 - H. Output shaft bearing
 - I. Spacer
 - J. Speedometer drive gear
 - K. Gasket
 - L. Bearing and seal housing
 - M. Seal
 - N. Nut
- VIII. Parts of shift lever housing and reverse stop plunger (Transparency 9)
 - A. Ball grip (shift knob)
 - B. Dust cover
 - C. Pin
 - D. Lock washer
 - E. Nut
 - F. Capscrew (4)
 - G. Housing
 - H. Gear shift lever

INFORMATION SHEET

- I. Washer
 - J. Spring
 - K. Shift yoke
 - L. Plunger
 - M. Plug
- IX. Parts of a shift bar housing (Transparency 10)
- A. Tension spring cover
 - B. Gasket
 - C. Tension spring
 - D. Tension ball (poppet ball)
 - E. Plug
 - F. Actuating plunger
 - G. Backup light pin
 - H. Shift bar housing
 - I. 1st-reverse shift bar
 - J. Spring
 - K. Plungers
 - L. 1st-reverse shift yoke
 - M. 2nd-3rd speed shift bar
 - N. Interlocking ball
 - O. 2nd-3rd speed shift yoke
 - P. Interlocking pin
 - Q. 4th-5th speed shift bar
 - R. 4th-5th speed shift yoke

INFORMATION SHEET

X. Parts of a remote shift control assembly (Transparency 11)

- A. Cover
- B. Set screw
- C. Finger outer shaft
- D. Gasket
- E. Rod and bracket assembly
- F. Rod
- G. Oil seal
- H. U-joint assembly
- I. Remote housing
- J. Plug
- K. Finger inner shaft
- L. Key

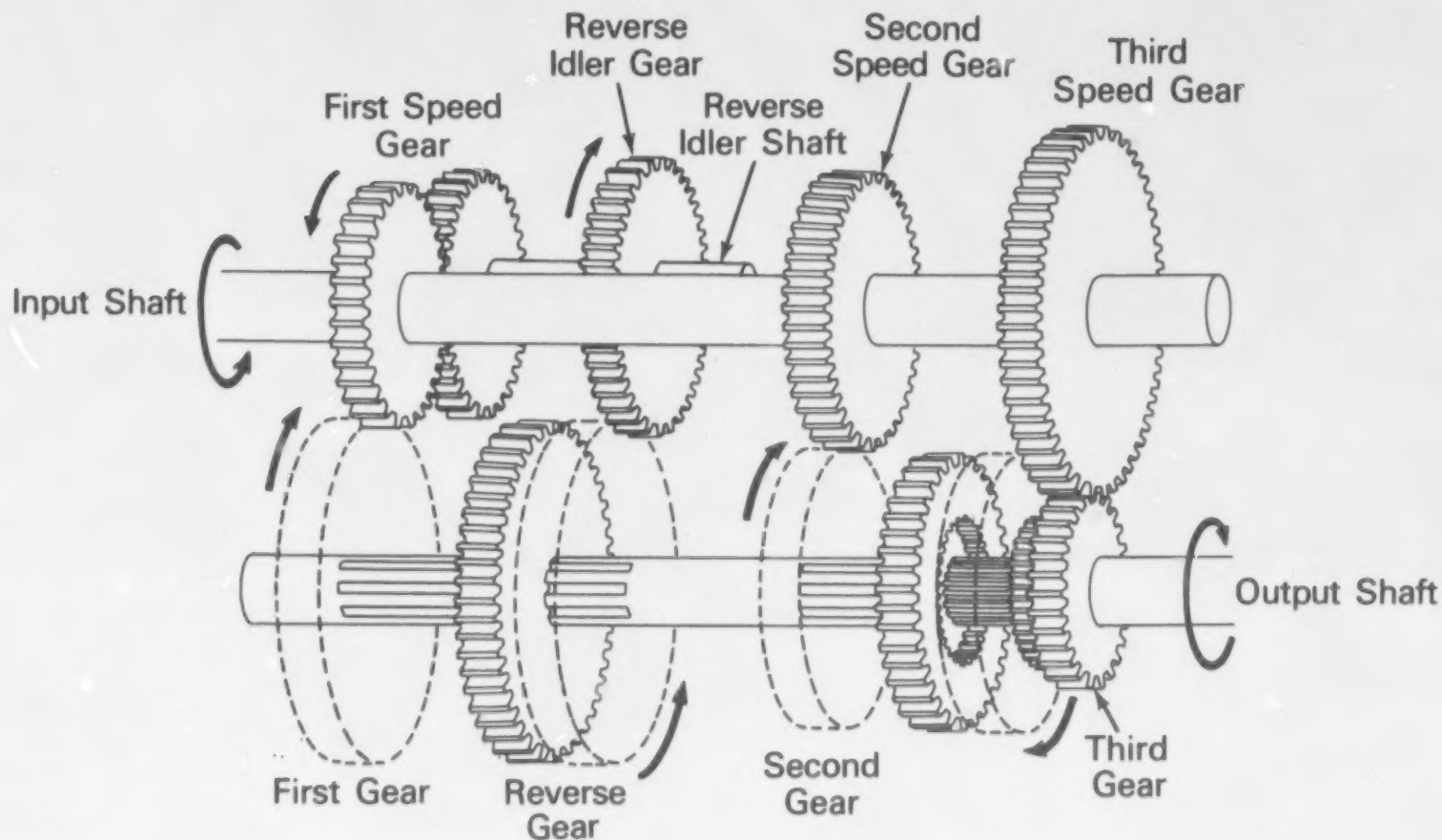
XI. Air flow for range shifting (Transparencies 12 and 13)

(NOTE: Constant air supply for all ranges is from regulator to slave air valve top rear connection, to control valve S connection, and to largest connection in intermediate shift cylinder.)

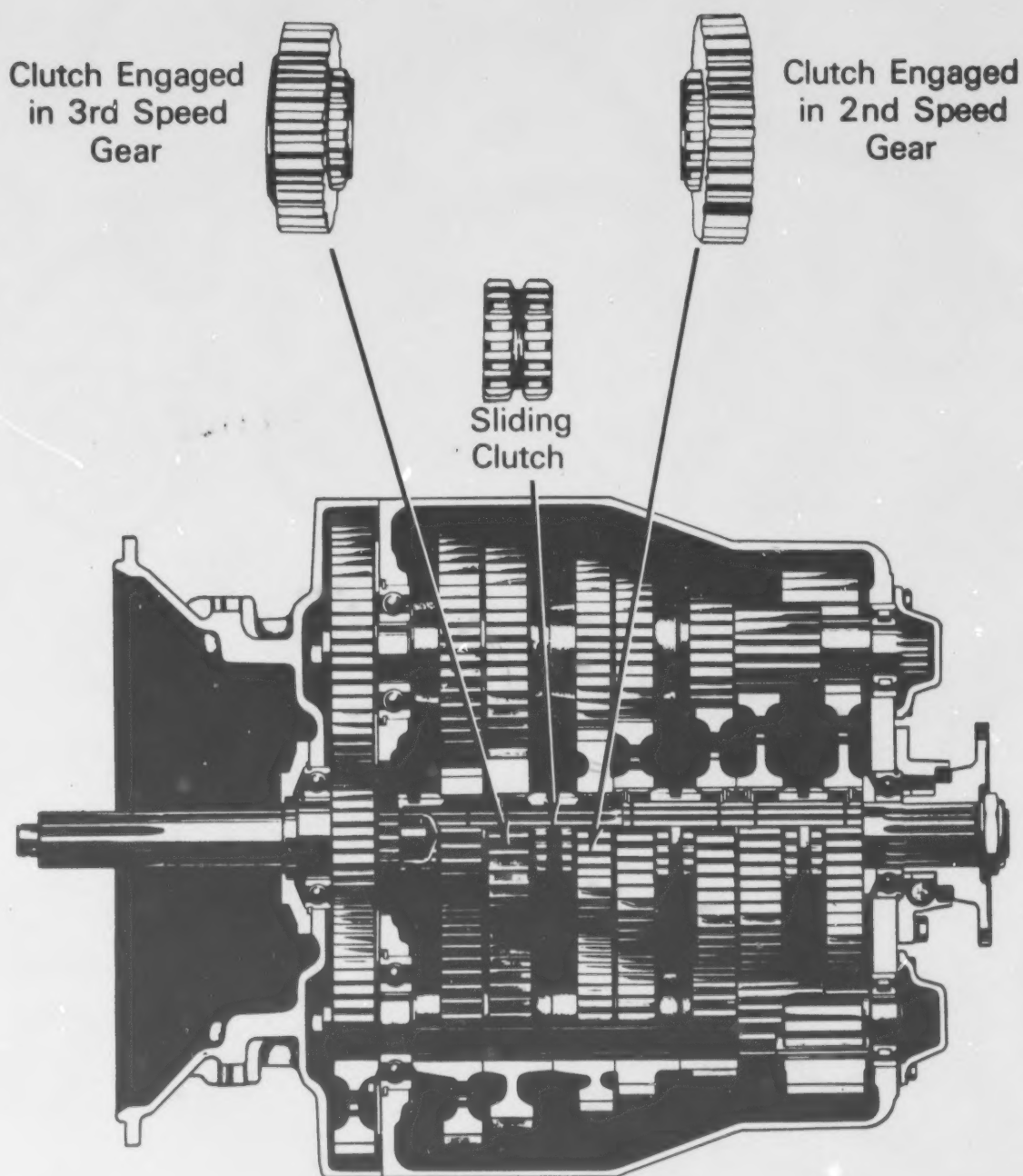
- A. Low range-Air from slave air valve, side connection, to front of auxiliary shift cylinder
- B. Intermediate range-Air from slave air valve front connection to front connection of auxiliary shift cylinder, and from control valve F connection to small line connection on intermediate shift cylinder
- C. Direct range-Air from slave air valve top connection to connection in rear of auxiliary shift cylinder and from control valve F connection to small connection on intermediate shift cylinder, and from control valve R connection to small front connection of slave air valve

(NOTE: Symbols for air flow schematics are: S = Supply, F = Feed, and R = Return.)

Sliding Gear Transmission with Shafts in Line

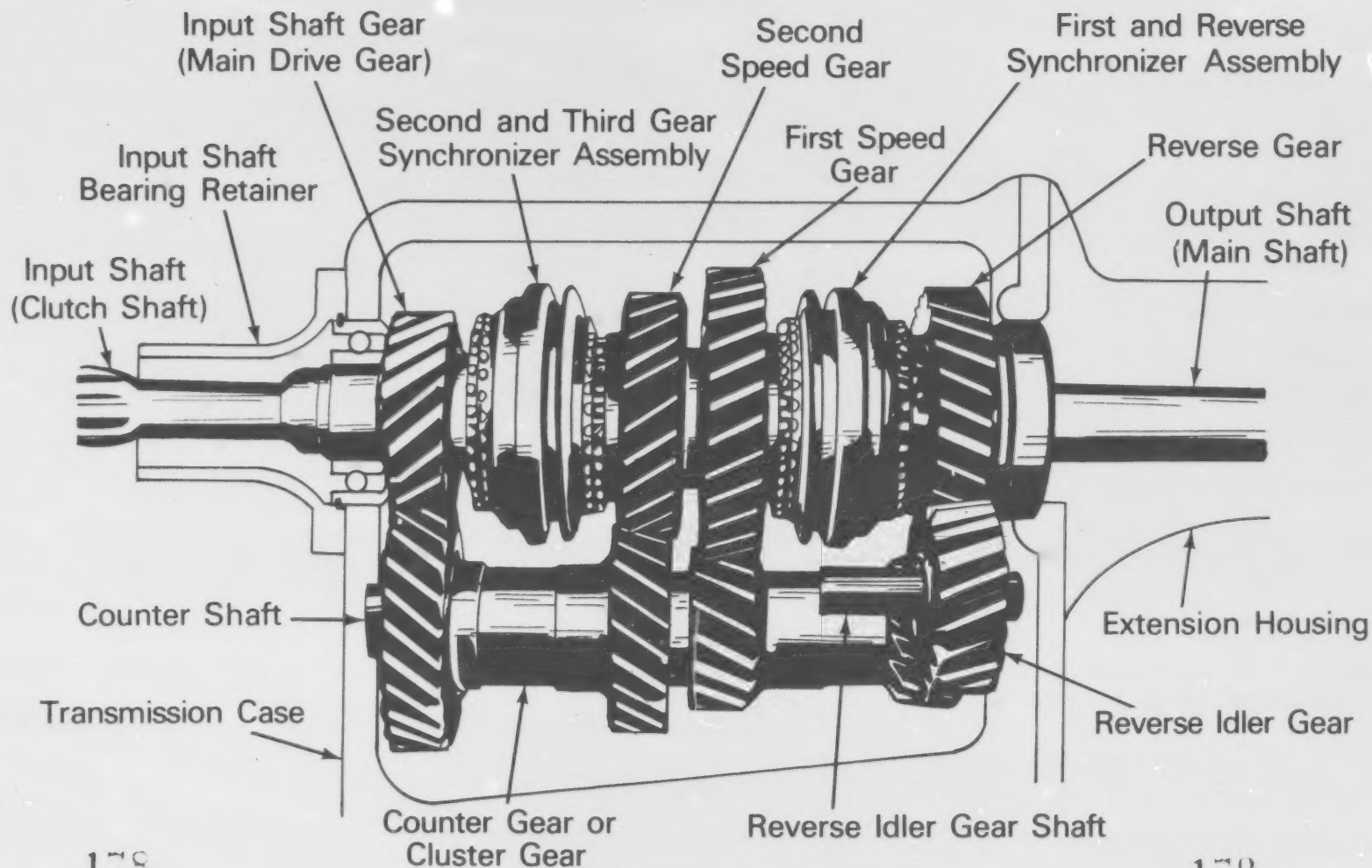


Sliding Clutch Transmission

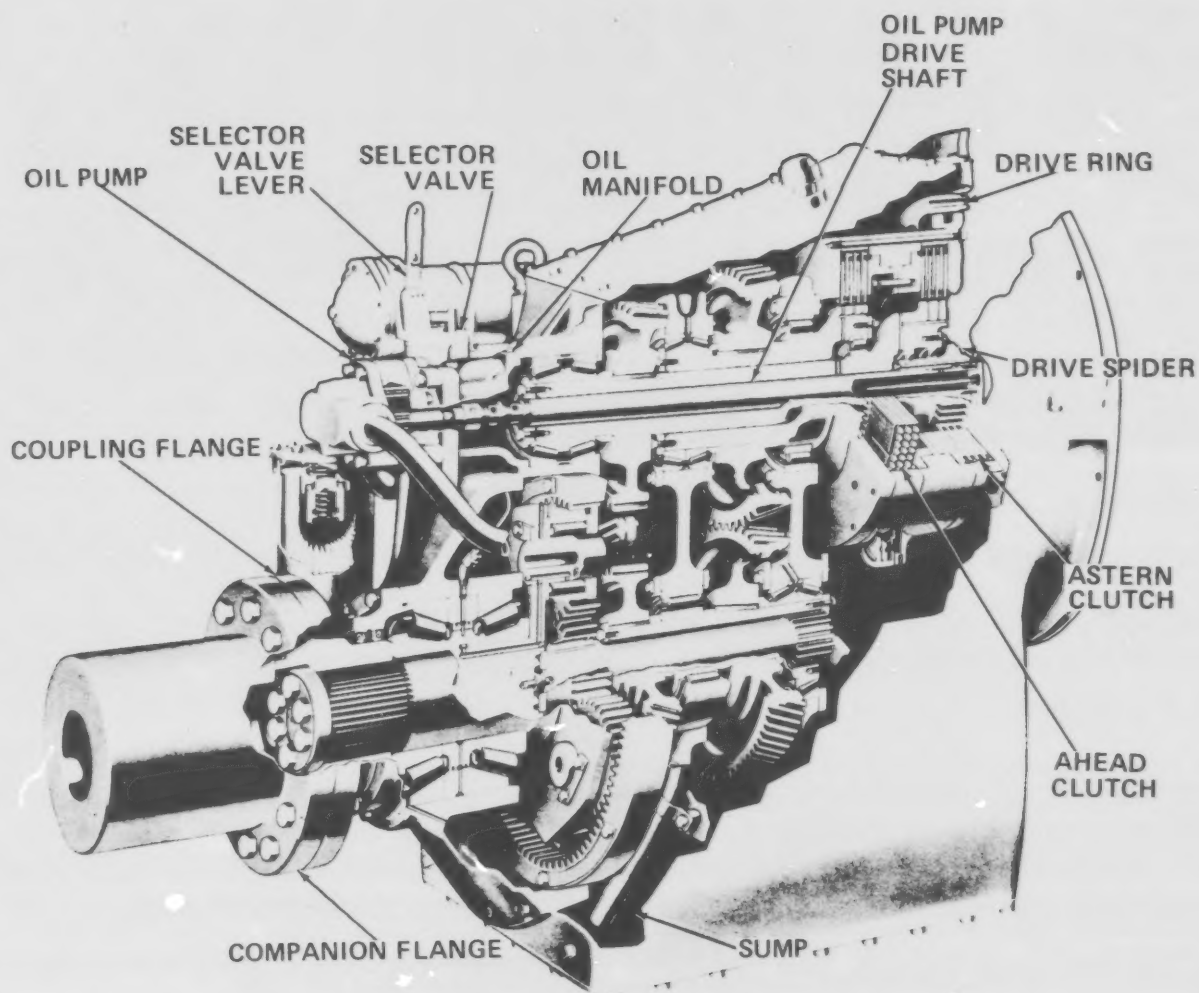


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Synchromesh Transmission

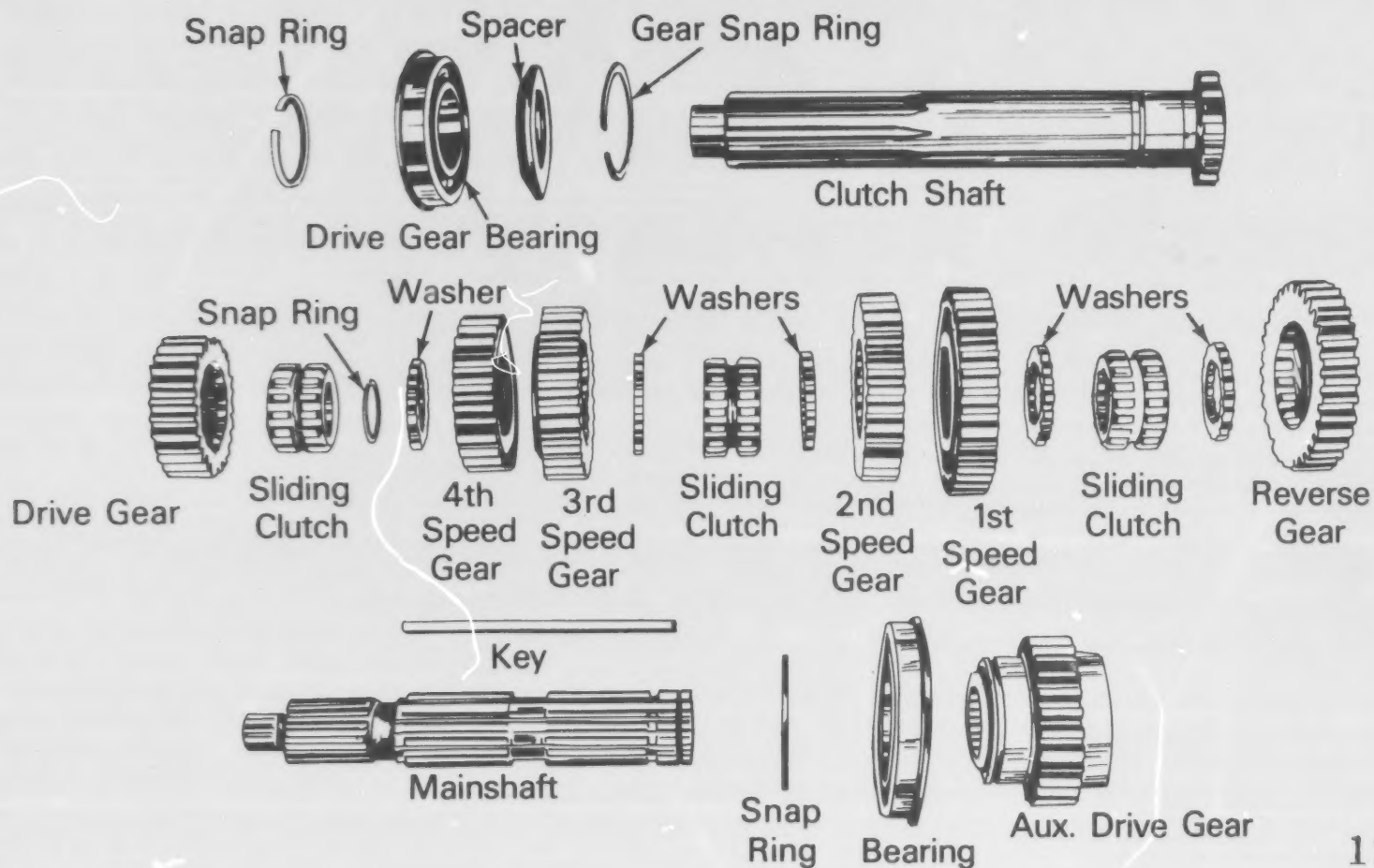


Marine Gear Transmission



Courtesy Caterpillar

Parts of Sliding Clutch Transmission Top Shaft Assembly

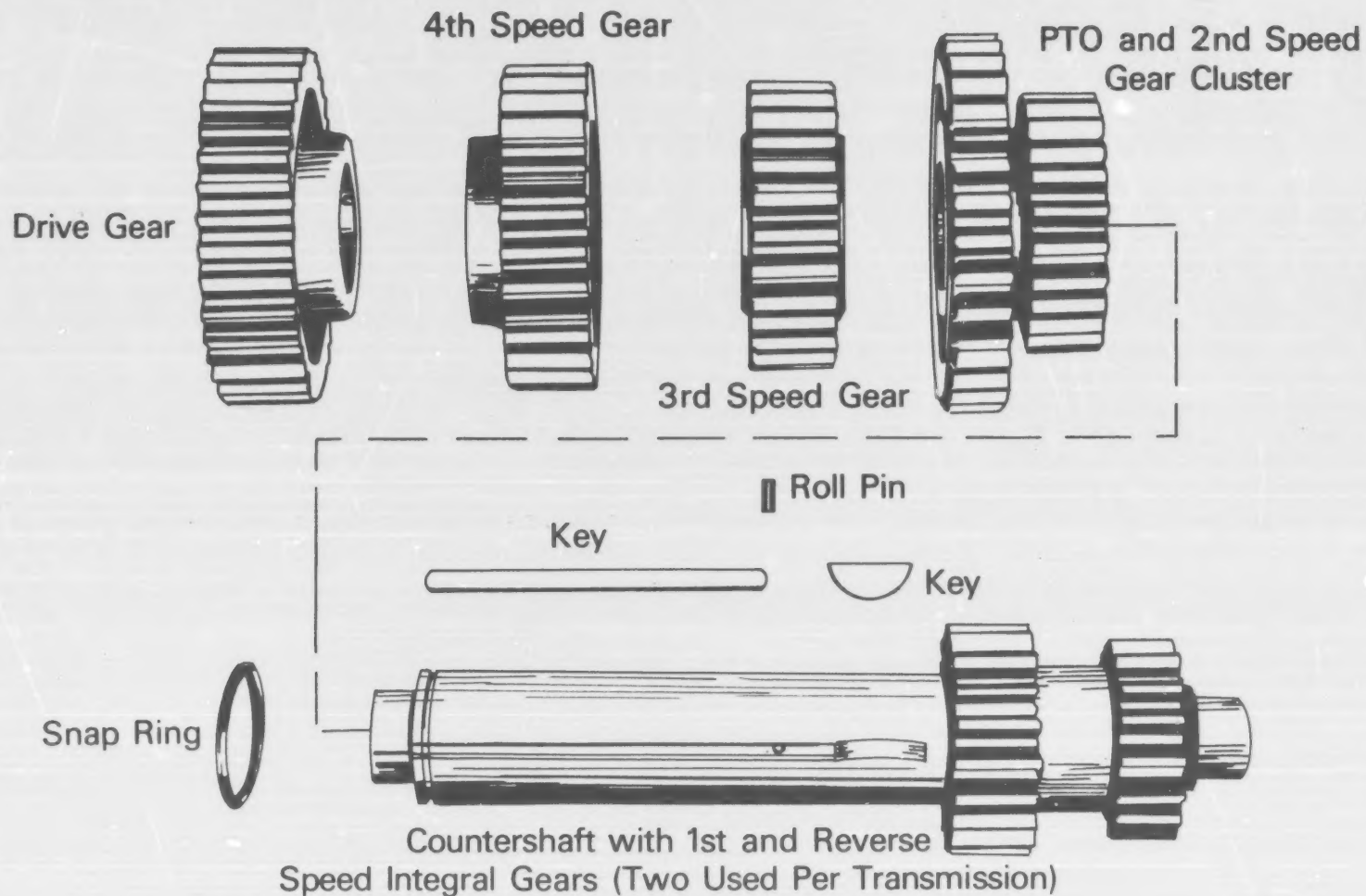


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Courtesy Transmission Division, Eaton Corporation

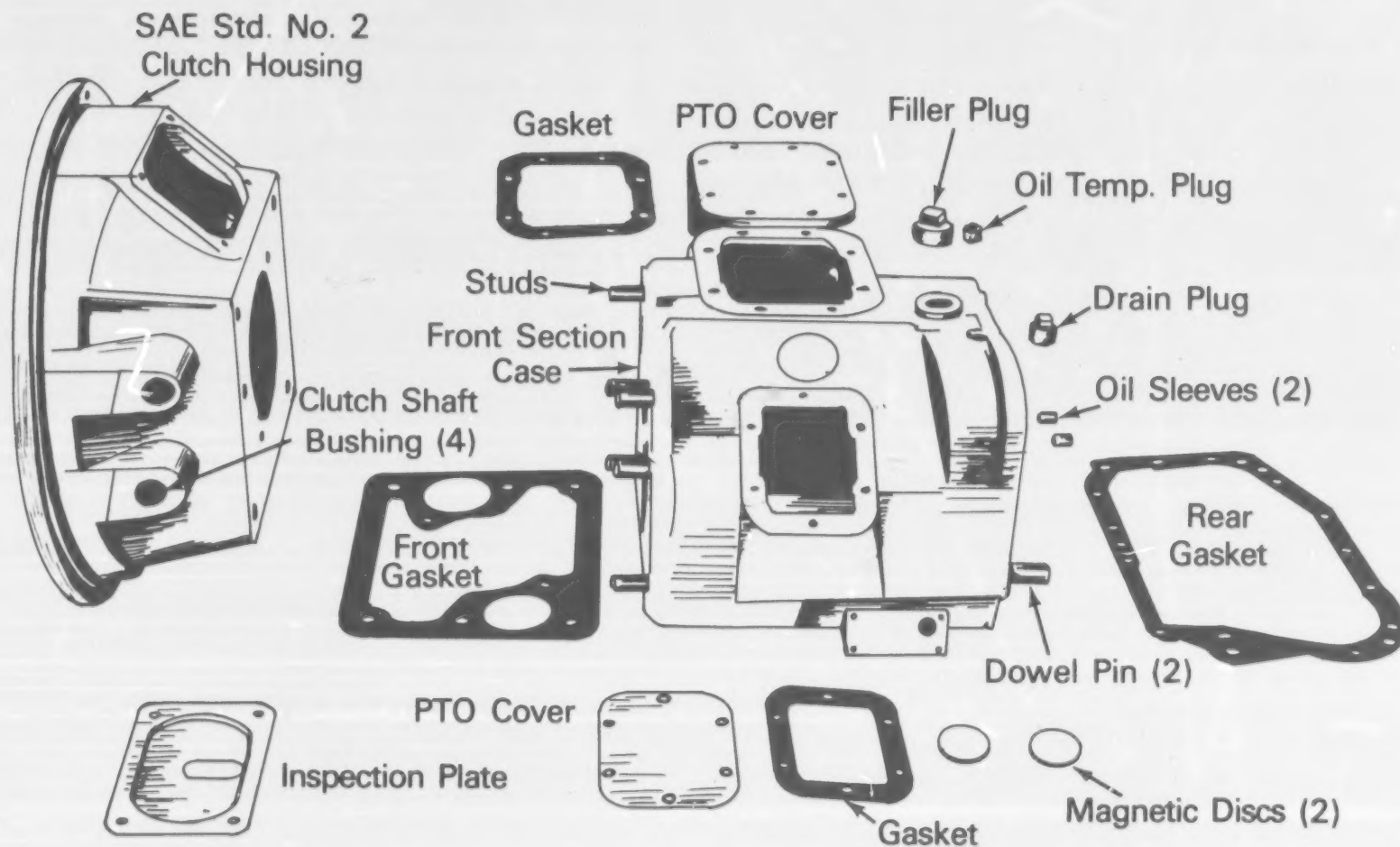
182

Parts of Front Section Countershaft

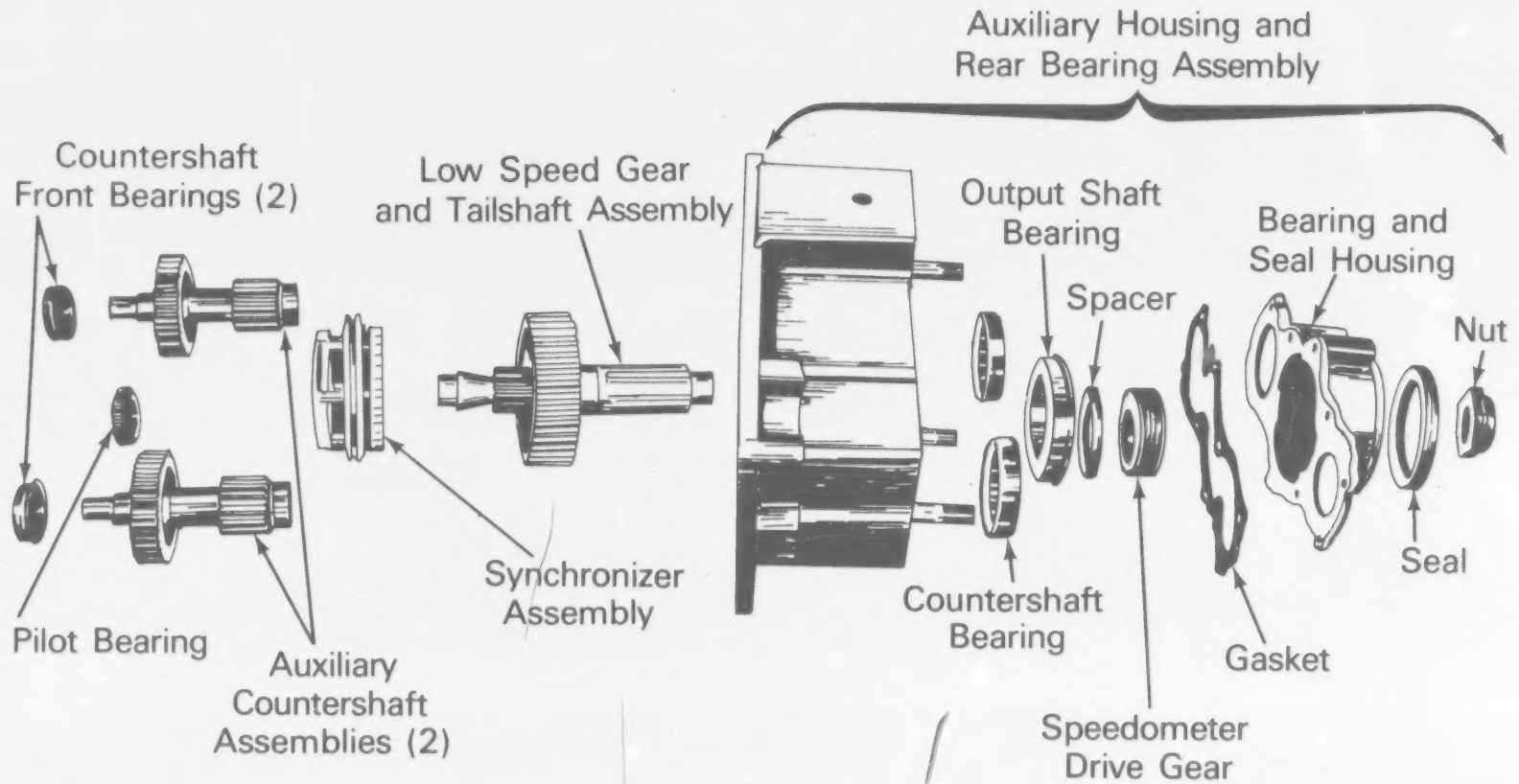


Courtesy Transmission Division, Eaton Corporation

Transmission Front Section Case with Clutch Housing

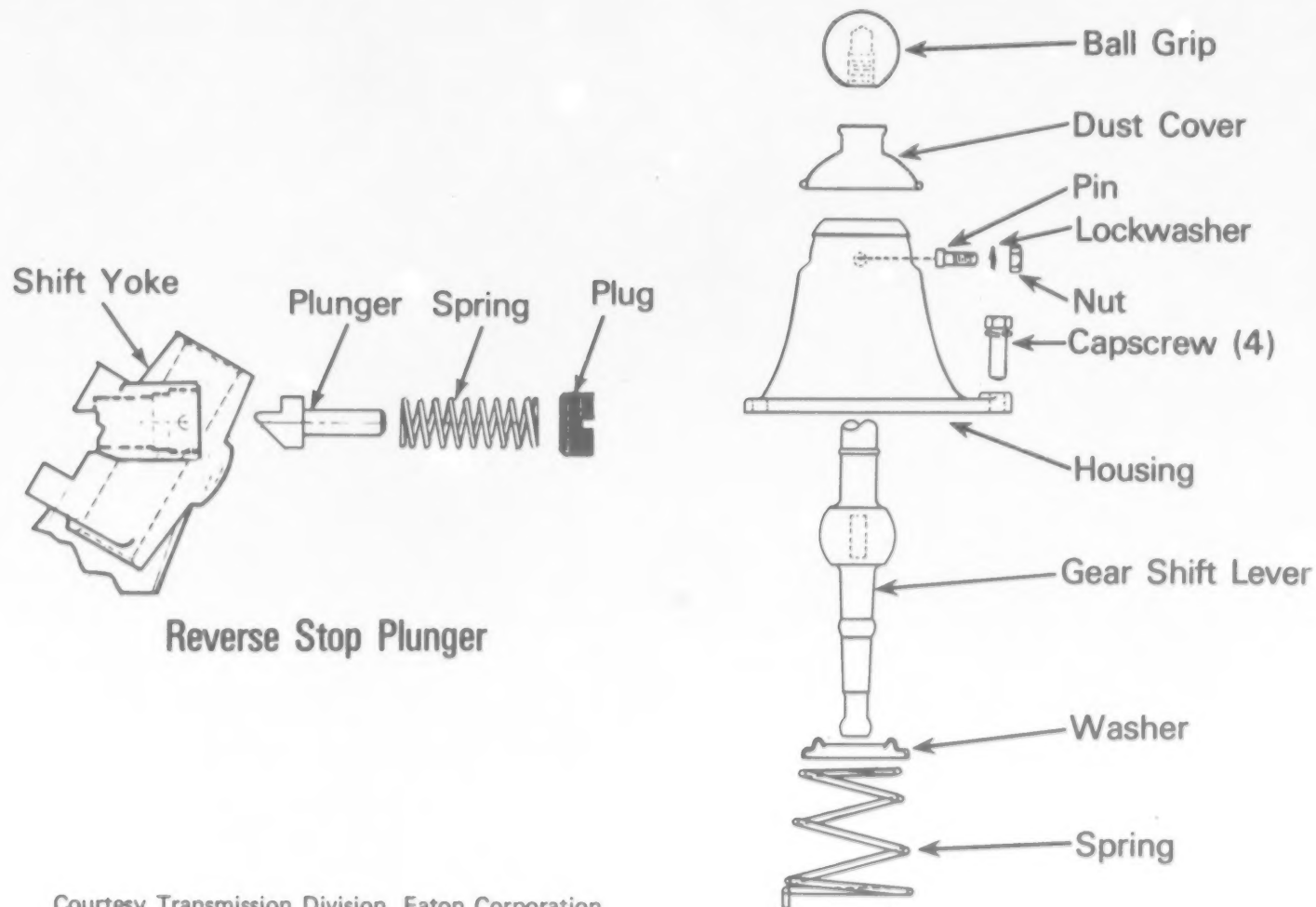


Parts of Auxiliary Section, Ten Speed Transmission



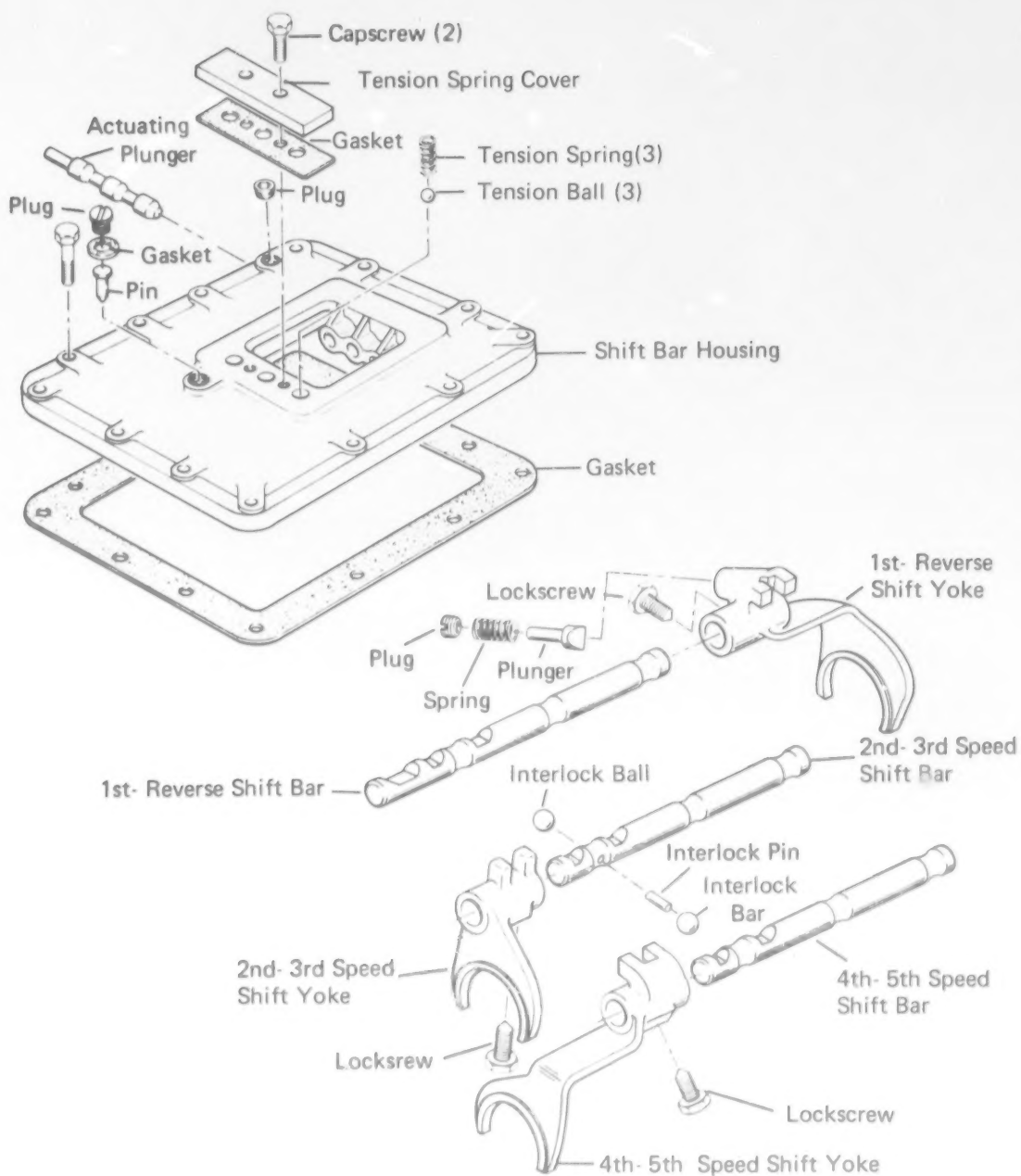
Courtesy Transmission Division, Eaton Corporation

Parts of Shift Lever Housing and Reverse Stop Plunger



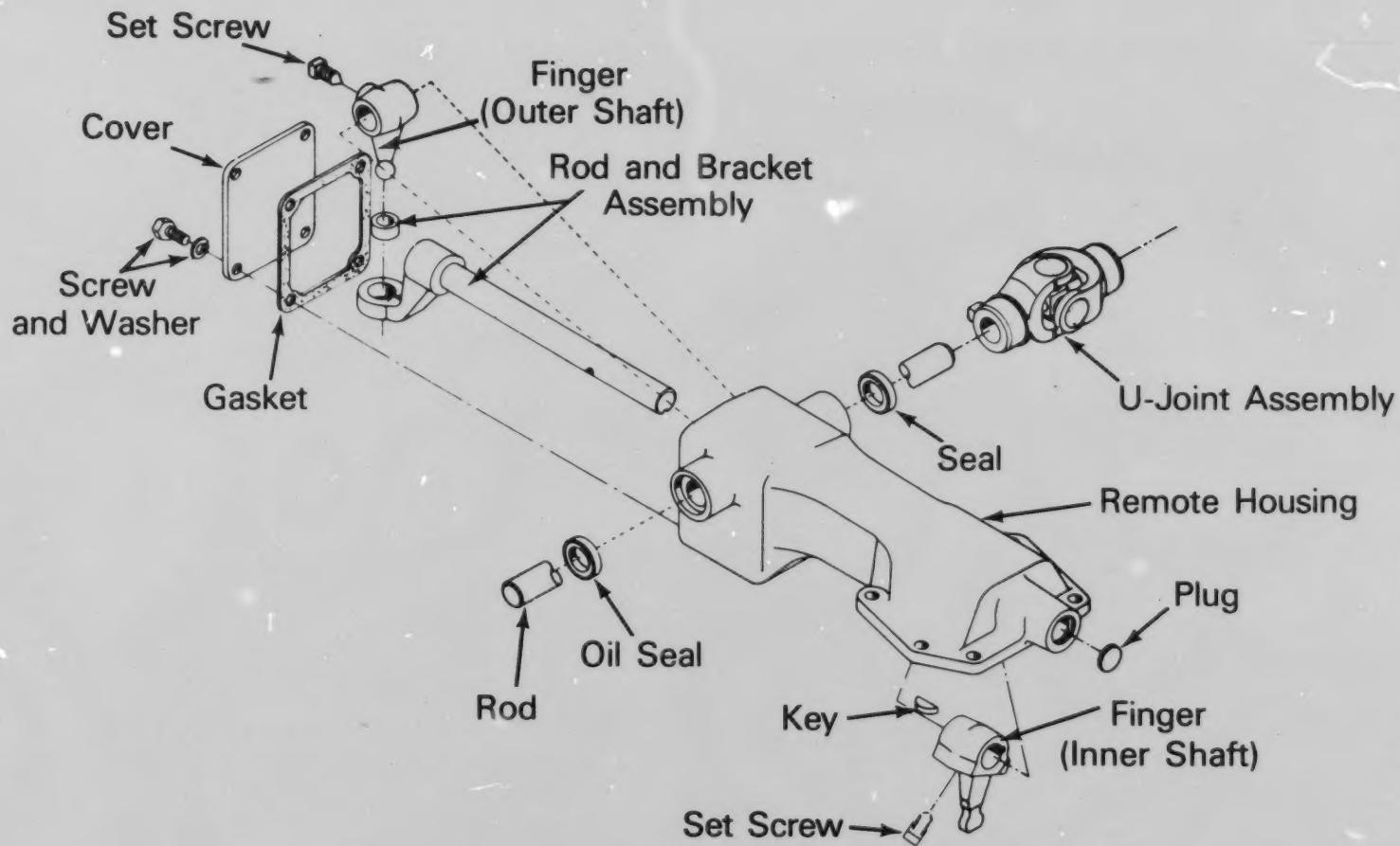
Courtesy Transmission Division, Eaton Corporation

Parts of Shift Bar Housing

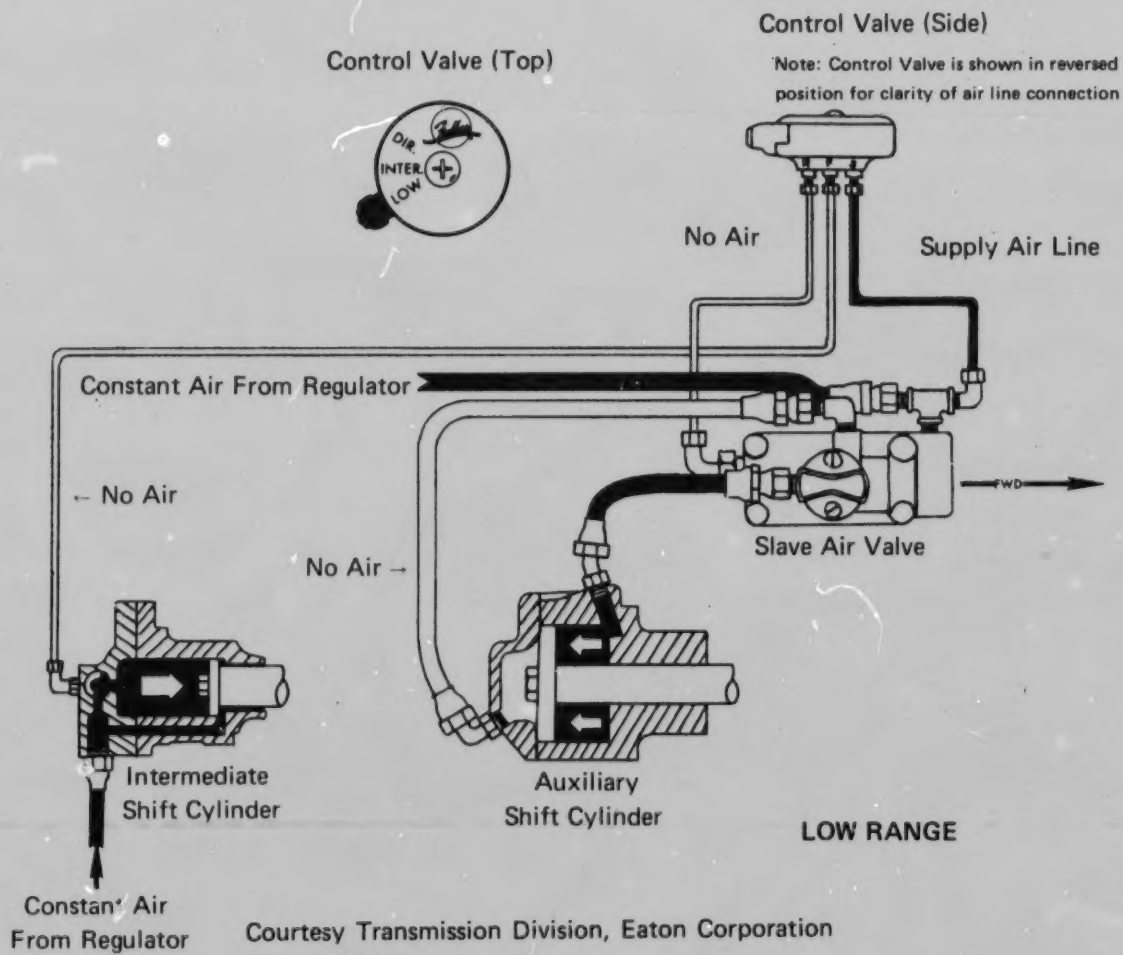


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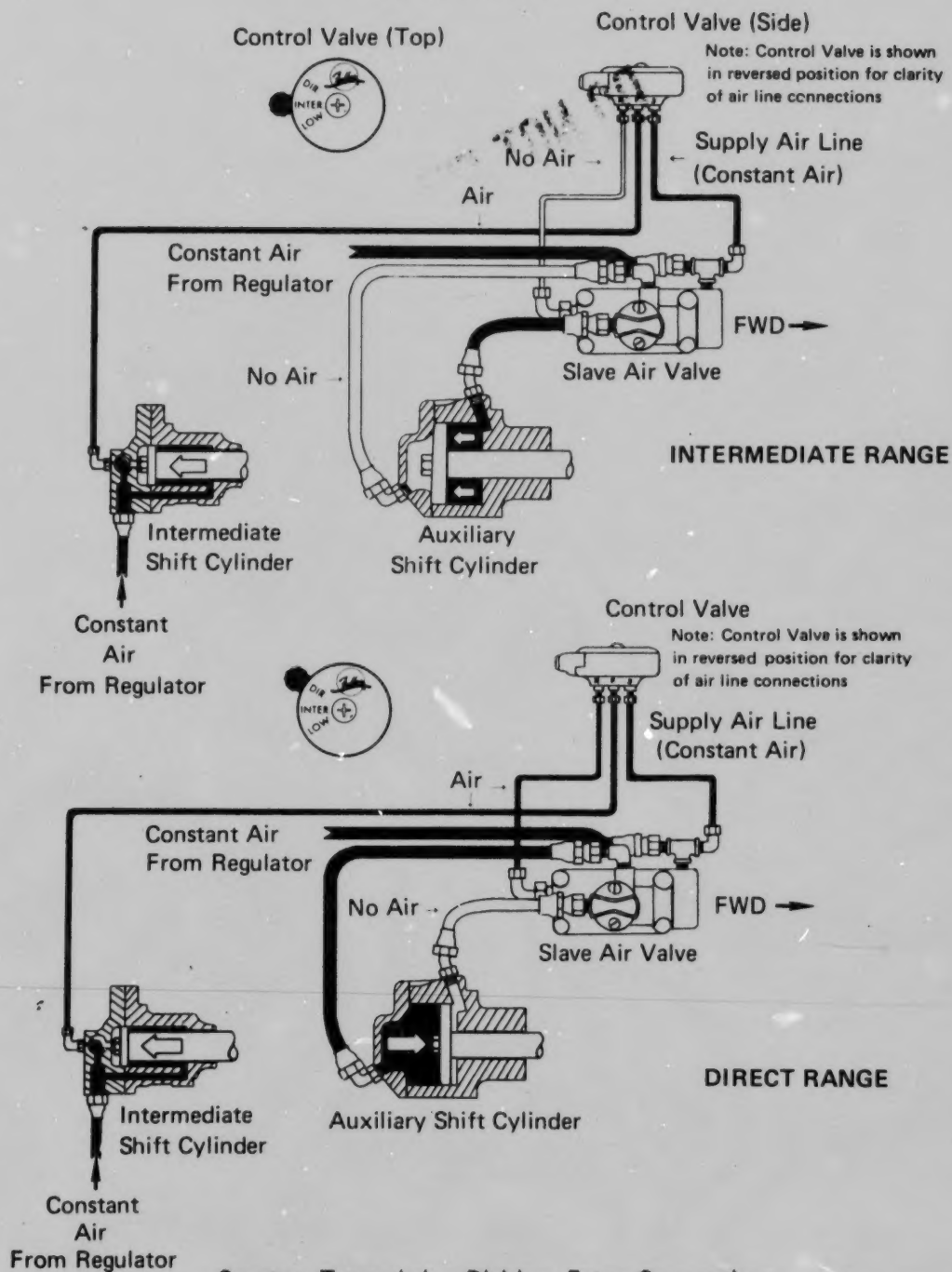
Remote Shift Control Assembly



Air Flow For Range Shifting



Air Flow For Range Shifting (Continued)

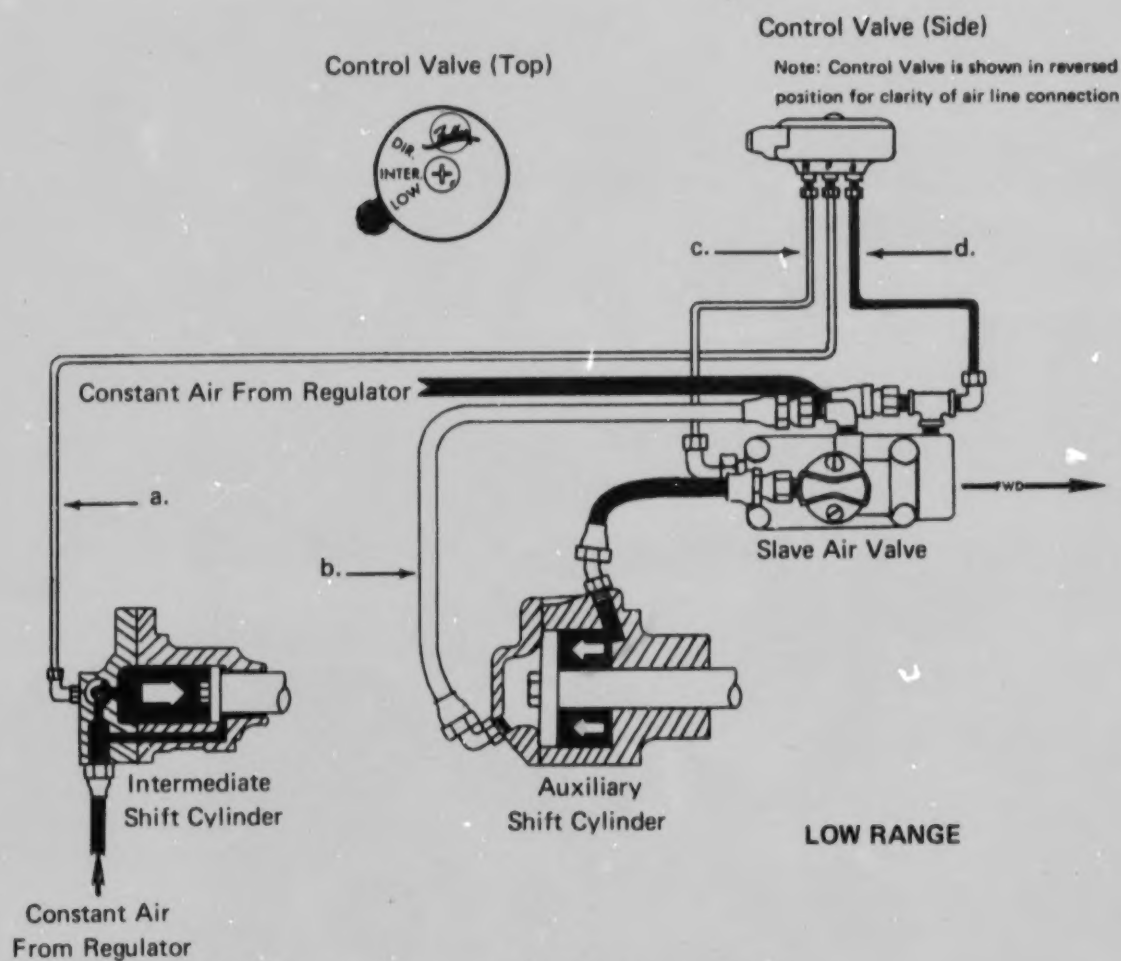


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MECHANICAL TRANSMISSIONS UNIT IV

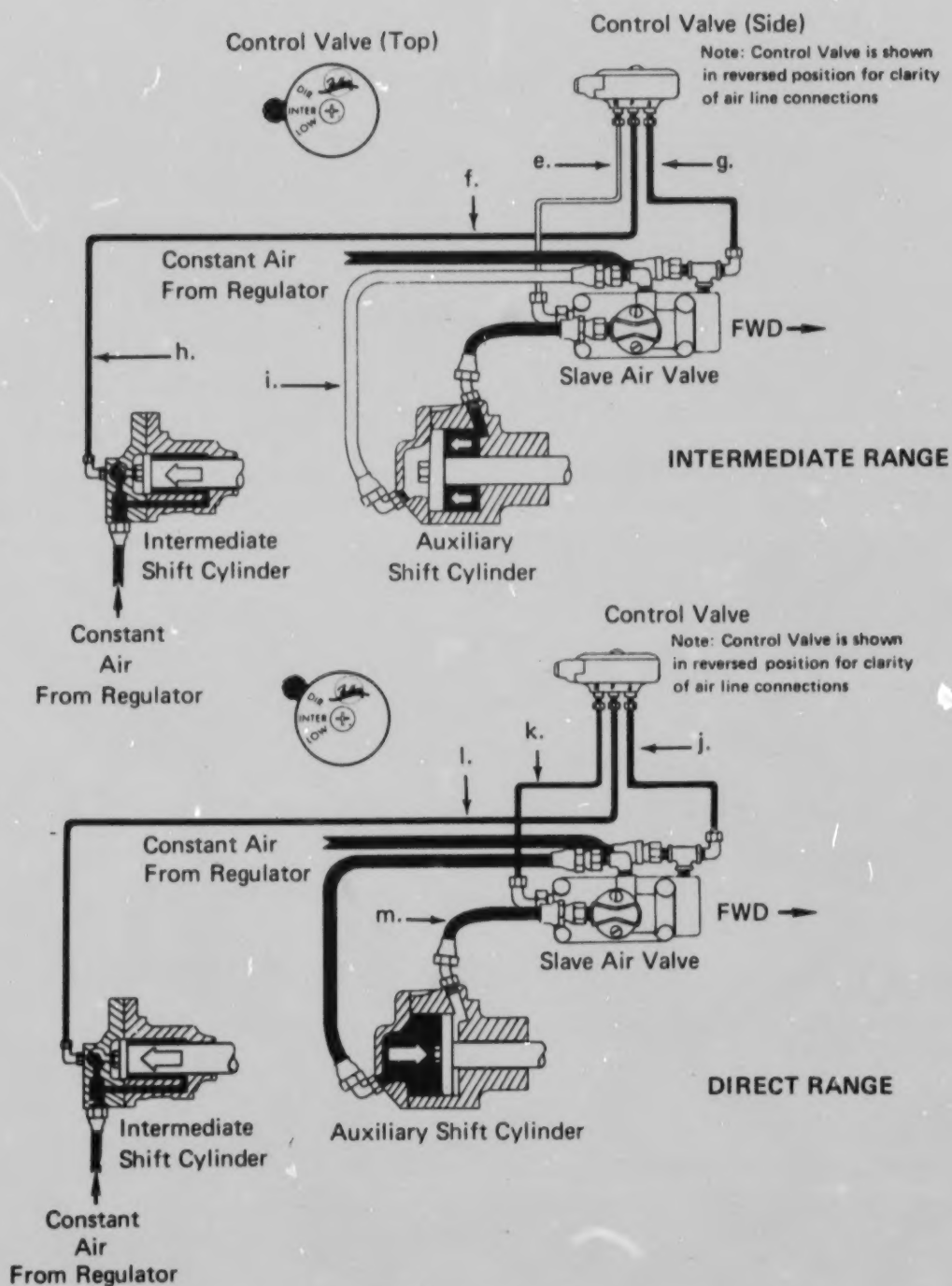
ASSIGNMENT SHEET #1--SHOW AIR FLOW IN AIR LINES FOR RANGE SHIFTING

Directions: Show air flow in air lines for range shifting by writing *air* or *no air* in the blanks in the following diagrams.



Courtesy Transmission Division, Eaton Corporation

ASSIGNMENT SHEET #1



Courtesy Transmission Division, Eaton Corporation

MECHANICAL TRANSMISSIONS
UNIT IV

ANSWERS TO ASSIGNMENT SHEET #1

- | | | | |
|----|--------|----|--------|
| a. | No air | g. | Air |
| b. | No air | h. | Air |
| c. | No air | i. | No air |
| d. | Air | j. | Air |
| e. | No air | k. | Air |
| f. | Air | l. | Air |

MECHANICAL TRANSMISSIONS UNIT IV

JOB SHEET #1--CHECK A MECHANICAL TRANSMISSION FLUID LEVEL

I. Tools and materials

- A. Shop towels
- B. Basic hand tool set
- C. Creeper
- D. Safety glasses
- E. Proper lubricants
- F. Drain pan
- G. Approved cleaning fluid
- H. Chock blocks
- I. Blue safety tag

II. Procedure

(CAUTION: Always use creeper, wear safety glasses, chock wheels, keep unauthorized people out of cab, and blue tag the ignition switch.)

- A. Place vehicle on level ground
- B. Put drain pan under check plug
- C. Clean area around plug
- D. Remove plug or plugs
- E. Check level of lubricant (Figure 1)

(NOTE: Lubricant should be at the bottom edge of plug hole.)

FIGURE 1



Courtesy Transmission Division, Eaton Corporation

JOB SHEET #1

- F. Use fluids recommended by vehicle manufacturer
- G. Visibly inspect transmission mounts and mount bolts
- H. Visibly inspect air lines (if so equipped) for cracks, worn spots, and leaks
- I. Visibly inspect transmission for leaks at front and rear seals and at gaskets
- J. Change fluid and filter as recommended by manufacturer

MECHANICAL TRANSMISSIONS
UNIT IV

JOB SHEET #2--REMOVE AND DISASSEMBLE A MECHANICAL TRANSMISSION

- I. Tools and materials
 - A. Basic hand tool set
 - B. Shop towels
 - C. Safety glasses
 - D. Inside snap ring pliers--large
 - E. Outside snap ring pliers--large
 - F. Snap ring pliers--medium (needle-point)
 - G. Bearing pullers--small
 - H. Drive gear bearing driver
 - I. Steam supply
 - J. Solvent
 - K. Appropriate service manual
 - L. Press
 - M. Maul
- II. Procedure
 - A. Remove GROUND cable from battery
 - B. Remove mechanical transmission per vehicle manufacturer's service manual
(CAUTION: Use proper eye protection.)
 - C. Remove air regulator and filter assembly
 - 1. Disconnect and remove the air lines, including line clamps
 - 2. Turn out cap screws and remove regulator and filter assembly

(NOTE: During disassembly, lay all parts on clean workbench in order of removal.)

(CAUTION: Use good housekeeping methods while disassembling transmission.)

JOB SHEET #2

D. Remove range shift control valve

1. Remove two nylon air lines, one at front of valve and one at rear of valve
2. Remove two air lines between the valve and cylinders on auxiliary
3. Remove cap screws holding air valve
4. Remove actuating spring and pin from bore in transmission (Figure 1)

FIGURE 1



E. Remove shift bar housing

1. Turn out cap screws
2. Jar housing to break gasket seal
3. Remove housing from transmission

F. Remove universal joint companion flange or yoke

1. Lock the transmission by engaging in two gears
2. Remove companion flange nut from output shaft
3. Pull flange or yoke straight to rear and off shaft

JOB SHEET #2

G. Remove auxiliary section

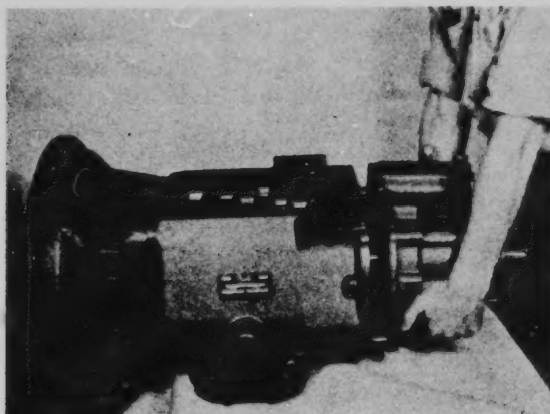
1. Turn out cap screws
2. Insert puller screws
3. Tighten puller screws evenly

(NOTE: Remove auxiliary section straight to the rear with puller screws.)

4. Remove auxiliary section from front section (Figure 2)

(CAUTION: Use proper lifting procedure.)

FIGURE 2



H. Remove clutch housing

1. Remove clutch release mechanism
2. Turn nuts from six studs
3. Break gasket seal
4. Remove clutch housing from case

JOB SHEET #2

I. Remove front bearing cover

1. Turn out cap screws

(NOTE: Tap against drive gear from inside case to move cover forward and break gasket seal.)

2. Remove cover

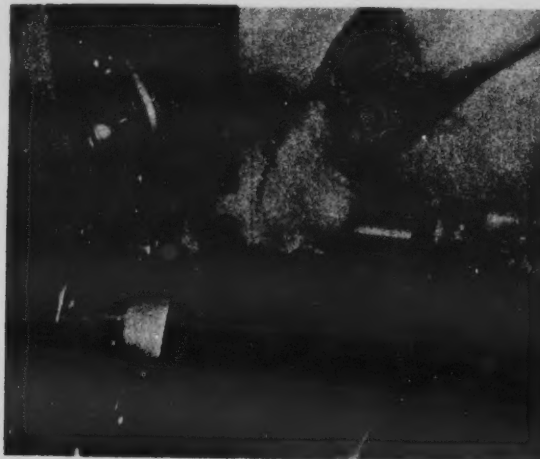
J. Remove bearings from right countershaft

1. Remove snap ring at rear of right countershaft

2. Using soft bar and maul against rear of shaft move assembly forward as far as possible until snap ring groove in front bearing is exposed (Figure 3)

(CAUTION: Use caution when using hammer.)

FIGURE 3



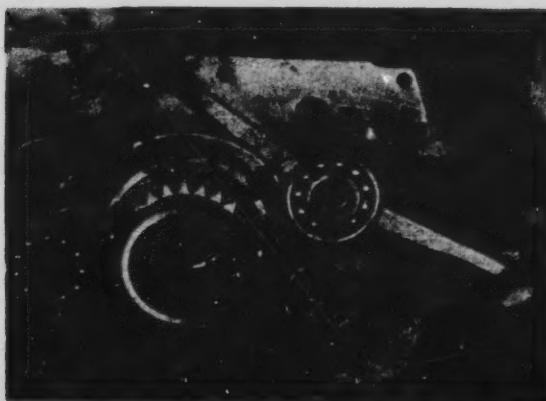
3. Install snap ring in groove in front bearing

(NOTE: Use snap ring removed from bearing bore.)

JOB SHEET #2

4. Using pry bars, remove front bearing from countershaft (Figure 4)

FIGURE 4



5. Using soft bar and maul from inside case, move countershaft to rear far enough to expose rear bearing snap ring groove
 6. Install snap ring in groove
 7. Use pry bar or puller to remove bearing (Figure 4)
- K. Remove clutch shaft bearing
1. Move drive gear forward as far as possible
 2. Remove bearing retainer snap ring (Figure 5)

FIGURE 5



JOB SHEET #2

3. Hold shaft in position and tap on side of shaft while pulling forward to unseat bearing from case

4. Use puller or pry bar to remove bearing

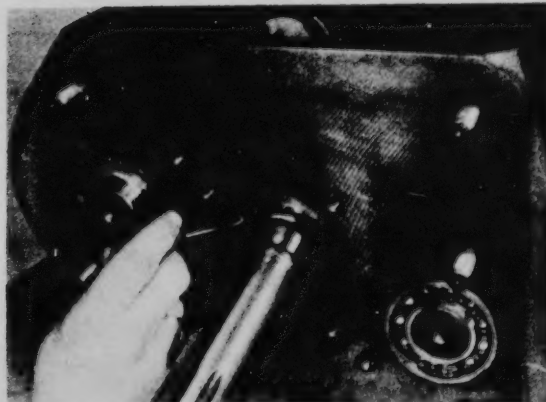
(CAUTION: Use proper tools for the job.)

L. Remove clutch shaft

1. Remove drive gear washer

2. Remove snap ring from groove in I.D. of gear (Figure 6)

FIGURE 6



3. Pull shaft forward from splines of drive gear

4. Move drive gear to rear against 4th speed gear engaging sliding clutch

M. Remove auxiliary drive gear assembly

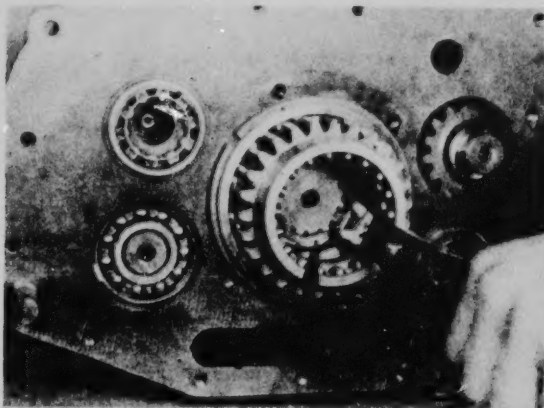
1. Turn out capscrews

2. Remove two bearing retainer rings

JOB SHEET #2

3. Remove snap ring from groove in mainshaft (Figure 7)

FIGURE 7

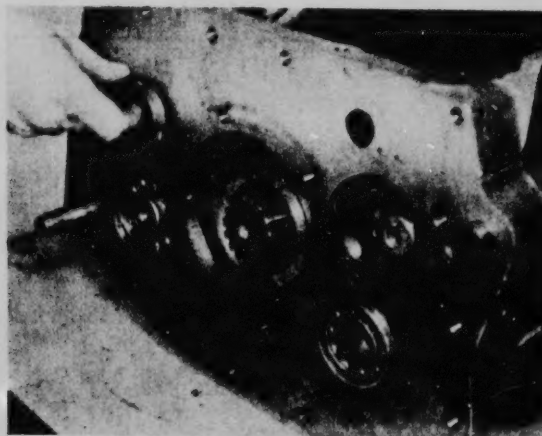


4. Tap against front of mainshaft to move drive gear bearing to the rear exposing bearing snap ring
 5. Use pry bar to remove auxiliary drive gear from case
- N. Remove bearing from auxiliary gear
1. Remove snap ring from gear
 2. Remove bearing from drive gear by using press or bearing driver
- O. Remove left reverse idler gear
1. Remove auxiliary countershaft front bearing from left reverse idler bore

JOB SHEET #2

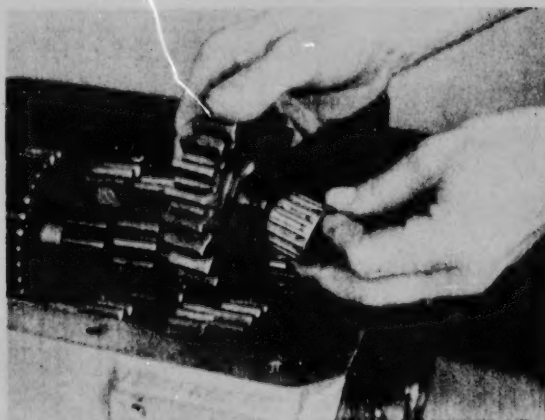
2. Remove rear idler washer and holder from bore of main case (Figure 8)

FIGURE 8



3. Remove reverse idler gear from case
4. Remove idler bearing from idler gear (Figure 9)

FIGURE 9

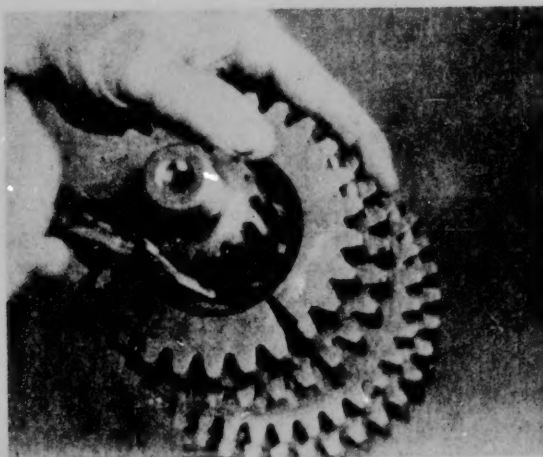


5. Remove front idler washer from case
- P. Remove and disassemble mainshaft
1. Block right countershaft to right as far as possible
 2. Lift mainshaft assembly from case
 3. Remove drive gear and 4th-5th sliding clutch from mainshaft

JOB SHEET #2

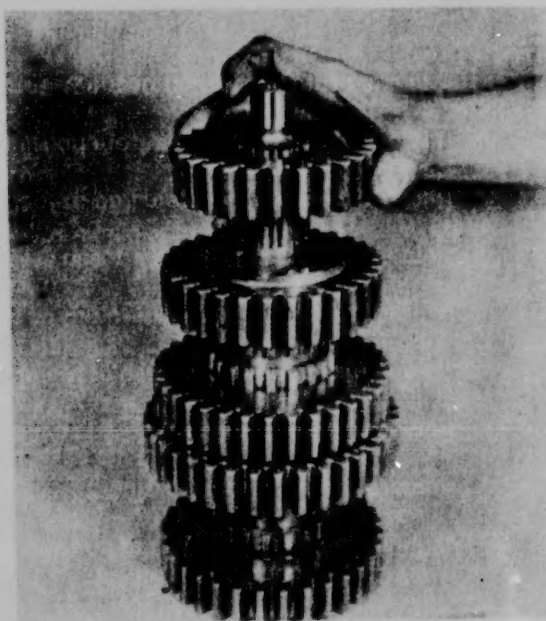
4. Remove 4th gear retaining snap ring from mainshaft (Figure 10)

FIGURE 10



5. Remove 4th gear and washer (Figure 11)

FIGURE 11



JOB SHEET #2

6. Remove 3rd gear and washer
7. Remove 2nd-3rd sliding clutch
8. Remove long key
9. Remove 2nd gear washer
10. Remove 1st gear and washer
11. Remove 1st reverse sliding clutch
12. Remove reverse gear and washer

Q. Remove countershaft assemblies

1. Lift right countershaft from case
2. Remove bearings from left countershaft in same manner as right (Refer to Figures 3 and 4)
3. Lift left countershaft from case

R. Remove right reverse idler gear

1. Remove auxiliary countershaft front bearing from right reverse idler gear bore
2. Remove rear idler washer and holder from bearing bore
3. Remove reverse idler gear from case
4. Remove idler bearing from gear
5. Remove front idler washer from case

S. Disassemble countershaft assemblies

(NOTE: Disassemble both countershafts in the same manner.)

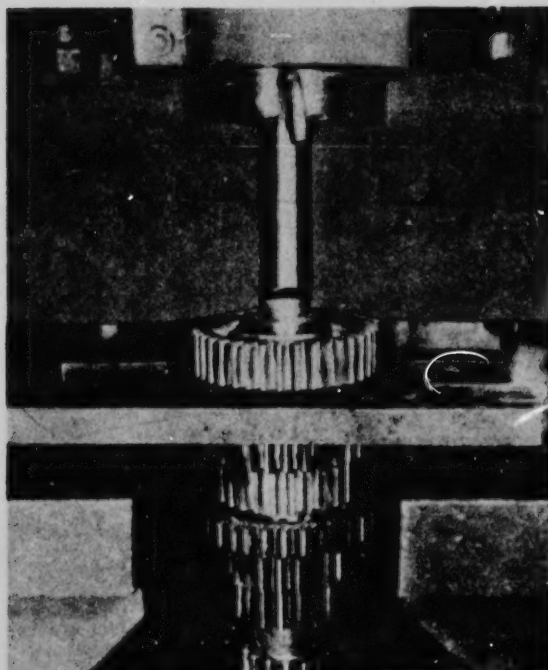
(CAUTION: Use caution when using press.)

1. Remove snap ring from front of countershaft

JOB SHEET #2

2. Press drive gear from shaft (Figure 12)

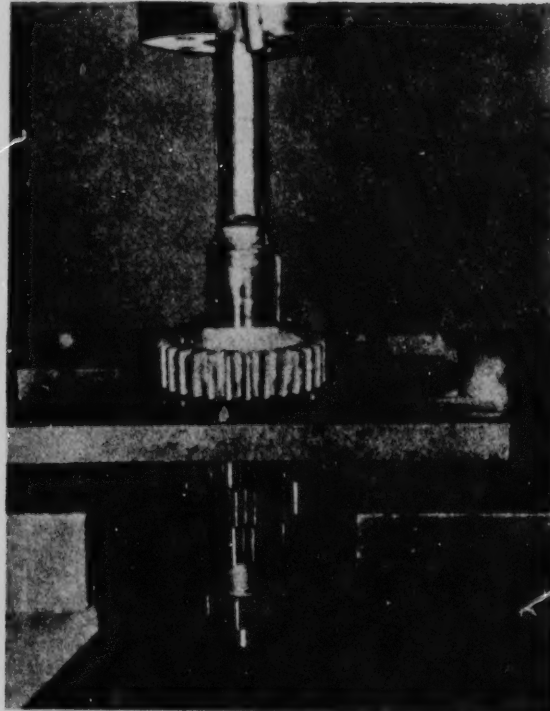
FIGURE 12



JOB SHEET #2

3. Press 4th gear from shaft (Figure 13)

FIGURE 13



4. Press PTO gear and 3rd gear from shaft by pressing on PTO gear
5. Remove woodruff key from shaft

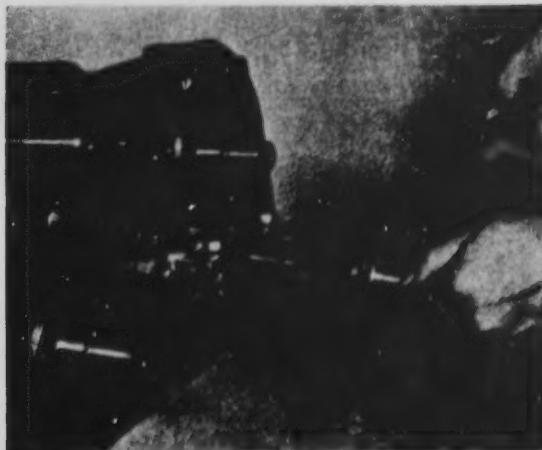
(NOTE: Do not remove woodruff key from shaft, unless key or shaft needs replacing.)

JOB SHEET #2

T. Remove auxiliary countershaft assemblies

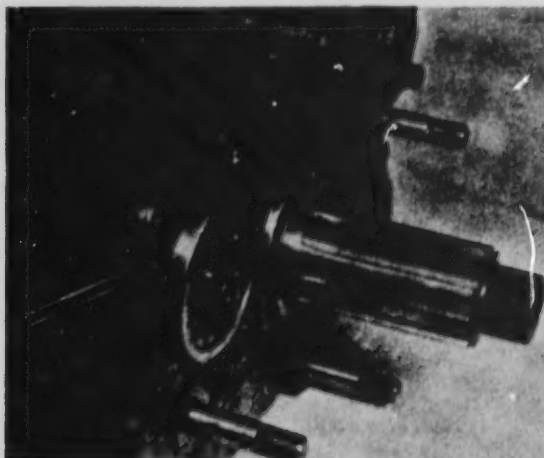
1. Remove bearing from front of tailshaft (Figure 14)

FIGURE 14



2. Turn out capscrews and remove rear bearing cover
3. Remove rear seal from cover
4. Remove speedometer gear and washer
5. Drive countershaft rear bearing outer race to rear about 1/2" (Figure 15)

FIGURE 15



(NOTE: From inside housing, use long punch to drive bearing race rearward.)

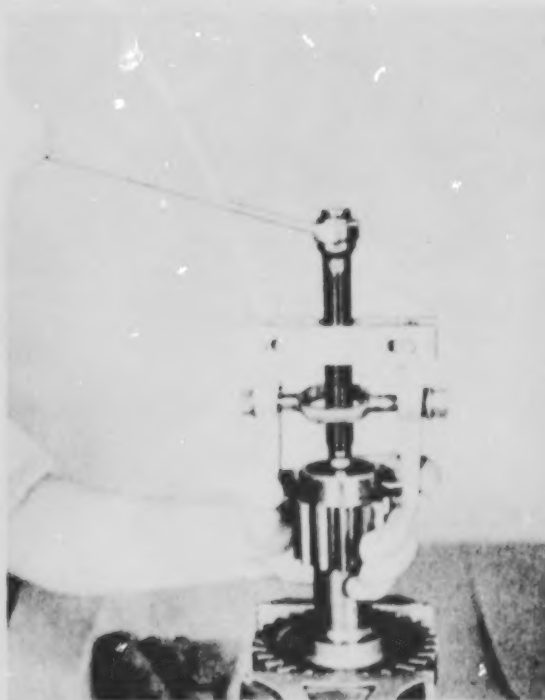
JOB SHEET #2

6. Remove countershafts

U. Disassemble auxiliary countershafts

1. Remove bearing inner race from rear of countershaft (Figure 16)

FIGURE 16



(NOTE: In late style transmissions, the drive gear is welded to the countershaft and cannot be removed.)

2. Remove snap ring
3. Press drive gear from shaft

V. Remove range shift cylinder and synchronizer

1. Turn out cap screws and remove cylinder cover
2. Remove nut holding air piston to shaft

JOB SHEET #2

3. Use air to remove piston (Figure 17)

(CAUTION: Don't use too much air pressure.)

FIGURE 17



4. Remove O-ring from piston
5. Remove copper seal from shaft
6. Remove synchronizer, shift yoke, and piston shaft as an assembly (Figure 18)

FIGURE 18



JOB SHEET #2

7. Cut lock wire, take out two lockscrews, and remove shift yoke from shaft

8. Place low synchronizer on bench, and by twisting remove high range synchronizer from pins

(CAUTION: There are 3 springs located in high range synchronizer which will be released as high range synchronizer is removed.)

9. Remove sliding clutch from low synchronizer pins

W. Remove and disassemble air cylinder

1. Remove dust seal and air port extension from top of housing

(NOTE: Air port extension has to be removed from cylinder before cylinder can be removed from housing.)

2. Remove cylinder from housing

3. Remove O-ring from small bore in cylinder

X. Remove and disassemble low speed gear and tailshaft

1. Drive or press tailshaft forward out of rear bearing

2. Remove rear washer and low speed gear

3. Remove spline washer from hub of low gear

4. Remove mainshaft bearing from housing

5. Remove countershaft rear bearings from housing

MECHANICAL TRANSMISSIONS UNIT IV

JOB SHEET #3-INSPECT TRANSMISSION PARTS

I. Tools and materials

- A. Safety glasses
- B. Air blow gun
(NOTE: Blow gun should be regulated at 30 P.S.I. output pressure)
- C. Solvent
- D. Shop towels
- E. Reusable parts guide
- F. Manufacturer's service manual

II. Procedure

A. Inspect all bearings

1. Wash all bearings

(CAUTION: Use approved cleaning solvent.)

2. Blow bearings dry with air

(CAUTION: Never let bearings spin while blowing dry with air, and use safety glasses.)

3. Check bearings for pits or spalls in inner races (Figures 1 and 2)

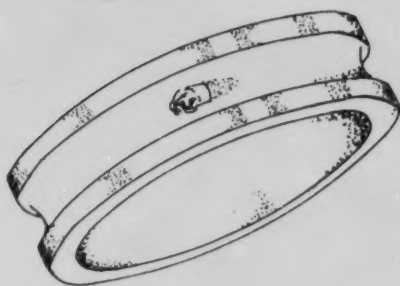


FIGURE 1

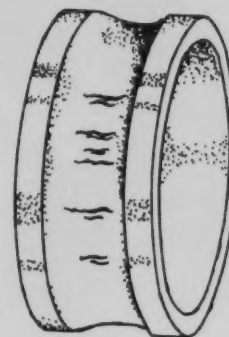


FIGURE 2

JOB SHEET #3

4. Check bearings for pitting or spalls in outer races (Figures 1 and 2)
5. Check bearings for pitting or spalls in roller or balls
6. Lubricate bearings
7. Check for axial looseness
8. Check for radial looseness
9. Replace bearings with excessive looseness
10. Wrap all reusable bearings

(NOTE: If transmission is high mileage overhaul--100,000 miles or more--all bearings should be replaced.)

B. Inspect all gears

1. Check gear for pitting on gear teeth faces (Figure 3)

(NOTE: Replace all gears with pitted teeth.)

2. Check engaging gears for tapered teeth (Figure 4)
3. Check engaging gears for worn or chipped teeth at engaging end



FIGURE 3

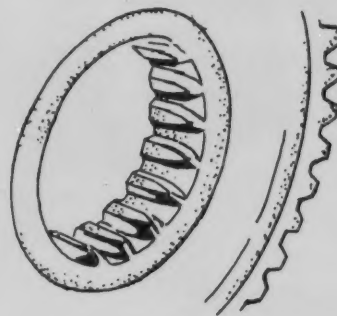


FIGURE 4

JOB SHEET #3

4. Check gear hubs for gaulding
5. Check gear hubs for excessive wear
6. Check gears for cracks (Figure 5)
7. Check gears for broken teeth (Figure 6)

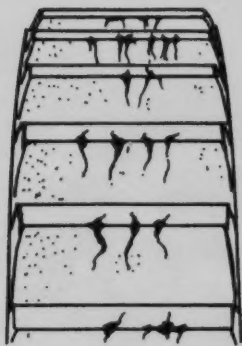


FIGURE 5



FIGURE 6

C. Inspect shafts

1. Check for bent shafts
2. Check for twisted shafts (Figure 7)

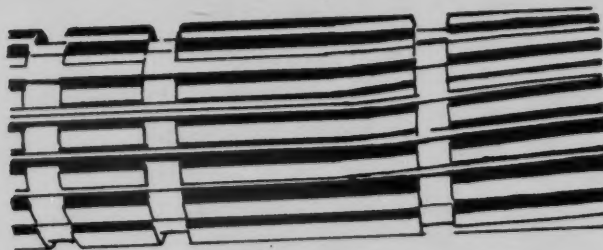


FIGURE 7

JOB SHEET #3

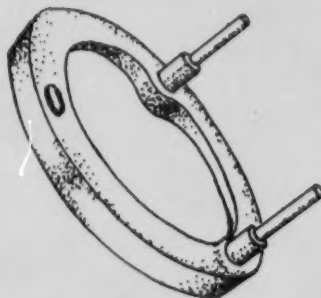
3. Check for worn splines
 4. Check cracks in shaft
 5. Check for gaulded splines
 6. Check for worn snap ring grooves
- D. Inspect thrust washers
1. Check surfaces for being scored (Figure 8)

FIGURE 8



2. Check washers for being reduced in thickness
- E. Inspect synchronizers
1. Check high and low synchronizers for wear at contact surfaces
 2. Check contact surfaces for heat damage
(NOTE: If contact surfaces are blue or black, they have been overheated.)
 3. Check blocker pins for excessive wear
 4. Check for loose or missing blocker pins (Figure 9)

FIGURE 9



JOB SHEET #3

5. Check synchronizer contact surfaces on high and low range gears for wear and burrs

F. Inspect cases

1. Check cases for cracks (Figure 10)

FIGURE 10



2. Check cases for worn bearing bores
 3. Check cases for damaged bolting surfaces
 4. Check cases for damaged bolt threads
- G. Inspect bearing and seal retainers
1. Check bearing retainers for worn bearing grooves and snap ring grooves
 2. Check to make sure seals in retainers are tight
 3. Check worn grooves in front retainer for wear

MECHANICAL TRANSMISSIONS
UNIT IV

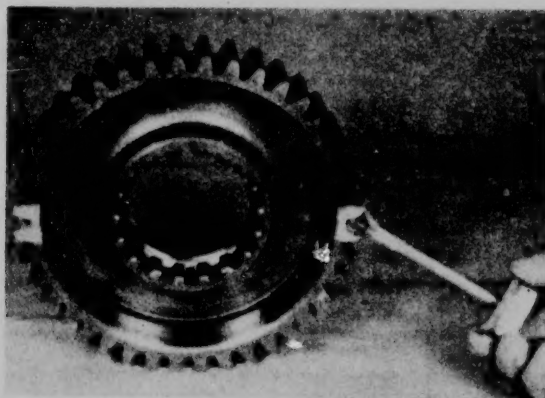
JOB SHEET #4--REASSEMBLE A MECHANICAL TRANSMISSION

- I. Tools and materials
 - A. Shop towels
 - B. Basic hand tool set
 - C. Creeper
 - D. Safety glasses
 - E. Large inside snap ring pliers
 - F. Large outside snap ring pliers
 - G. Bearing drivers
 - H. Seal drivers
 - I. Medium needlepoint snap ring pliers
 - J. Appropriate service manual
 - K. Press
 - L. Paint
 - M. Small paint brush
 - N. Large torque wrench (ft. lb. torque wrench)
- II. Procedure
 - A. Reassemble and install low speed gear and tailshaft
 - 1. Place magnetic cleaner in auxiliary case

JOB SHEET #4

2. Mark timing teeth on low speed gear (Figure 1)

FIGURE 1

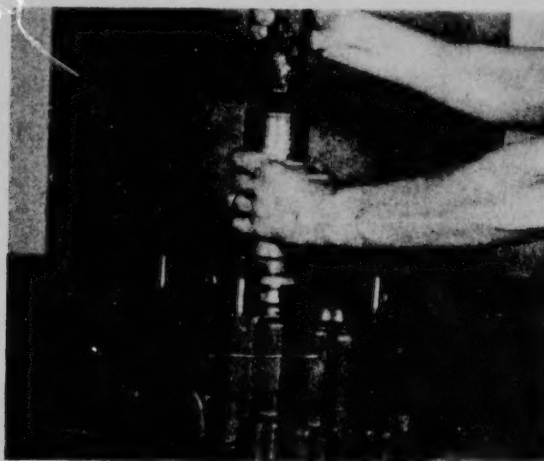


(NOTE: Paint two adjacent teeth, then paint two adjacent teeth straight across from the first two.)

3. Place splined washer in low speed gear hub with shoulder to the rear
4. Install low speed gear on tail from the rear with clutching teeth forward
5. Install low speed gear thrust washer, chamfer to rear
6. Place auxiliary housing over tailshaft
7. Install tailshaft bearing (Figure 2)

(NOTE: Use bearing driver and seat bearing on shaft and in case.)

FIGURE 2



JOB SHEET #4

B. Install air cylinder for range shifting

1. Install O-ring in groove in small bore of air cylinder
2. Install air cylinder in auxiliary case with air port in line with port in top of case
3. Install air port extension with dust cover (Figure 3)

FIGURE 3



C. Reassemble range synchronizer

1. Place low range synchronizer on bench with pins up
2. Place sliding clutch on pins with recessed side up
3. Place three springs in bores in high range synchronizer ring (Figure 4)

JOB SHEET #4

4. Install high range synchronizer ring over pins in low range synchronizer; take care not to damage springs in high range synchronizer

FIGURE 4



D. Install range synchronizer and shift fork in auxiliary case

1. Install shifting fork on piston shaft, fork toward threaded end
2. Align slots in shaft with bores in yoke hub and install lockscrews and safety wire
3. Place yoke in groove of sliding clutch; slide piston shaft with synchronizer assembly into rear case with piston shaft threaded end going into bore of air cylinder and synchronizer over tailshaft
4. Install copper seal on piston shaft (Figure 5)

FIGURE 5



JOB SHEET #4

5. Install O-ring over air piston (Figure 6)

FIGURE 6



6. Install piston on piston shaft and secure with lockwasher and nut

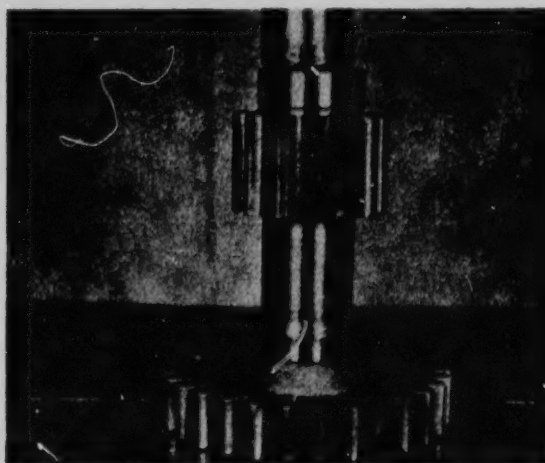
7. Install gasket and cylinder cover securing with four capscrews

E. Reassemble the countershafts

(NOTE: In late models, the drive gears are welded onto shaft.)

1. Install keys in shafts
2. Press gears on shafts with long hubs to the rear (Figure 7)

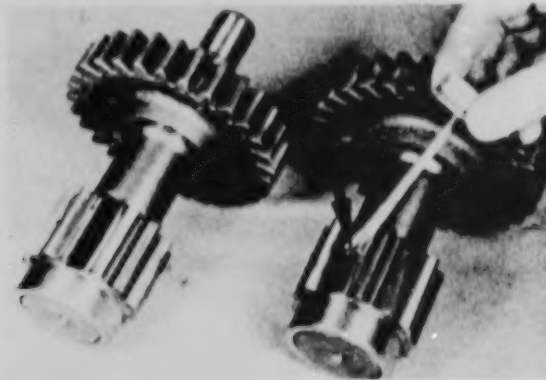
FIGURE 7



JOB SHEET #4

3. Install snap rings
 4. Install bearing inner races on rear of shafts
- F. Mark timing teeth on countershafts
1. Find tooth on low speed gears aligned with keyway in drive gear (Figure 8)
 2. Mark timing tooth on low speed gears with paint (Figure 8)
- (NOTE: Timing teeth will be marked with an "O" on the end.)

FIGURE 8



- G. Install countershafts
1. Seat rear bearings outer races into cases about two-thirds of the way in
 2. Place countershafts into case with marked tooth on low drive gear between two marked teeth on low driven gear (Figure 9)

JOB SHEET #4

3. Drive ~~the~~ bearing outer races the rest of the way into case and onto shaft

FIGURE 9



H. Install speedometer gear washer and speedometer gear

1. Install speedometer gear washer on tailshaft with chamfered inside diameter toward bearing (Figure 10)
2. Install speedometer gear, or replacement spacer, on tailshaft (Figure 10)

FIGURE 10



JOB SHEET #4

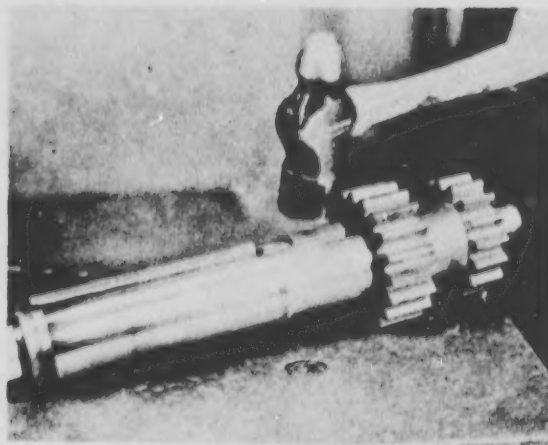
- I. Install seal in rear seal retainer and install retainer
 - 1. Drive rear seal into retainer with lip of seal toward the inside
 - 2. Install rear seal retainer with speedometer bore up and to the left
 - 3. Install cap screws and tighten
- J. Install front pilot bearing on tailshaft
- K. Install magnetic cleaner in bottom of main transmission case
- L. Install right reverse idler gear front washer on pin in lower right of case
 - 1. Install small reverse idler gear front washer on pin in lower right of case
 - 2. Place reverse idler gear in case with machined surface of gear hub to rear
 - 3. Place rear washer in holder with oil grooves down and bend lugs to hold washer in
 - 4. Install reverse idler gear bearing
 - 5. Install holder, with washer, into rear countershaft bore
 - 6. Install rear countershaft front bearing in bearing bore of front case

(NOTE: Front of auxiliary countershaft is journal for idler gears.)
- M. Assemble front countershafts
 - 1. Install roll pin (Figure 11)
 - 2. Install woodruff key

JOB SHEET #4

3. Install long key (Figure 11)

FIGURE 11

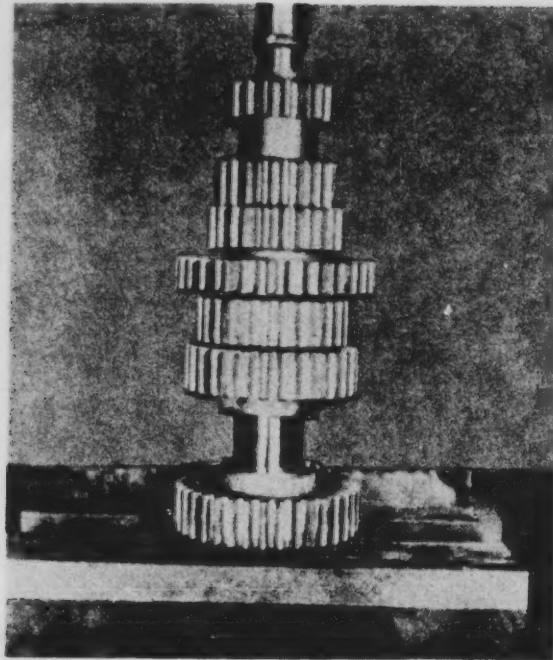


4. Press PTO-2nd speed gear cluster onto countershaft with PTO gear forward
5. Press 3rd speed gear on with long hub to rear
6. Press 4th speed gear on with long hub to front
7. Press drive gear on with long hub to rear (Figure 12)

JOB SHEET #4

8. Install snap ring on front of shaft

FIGURE 12



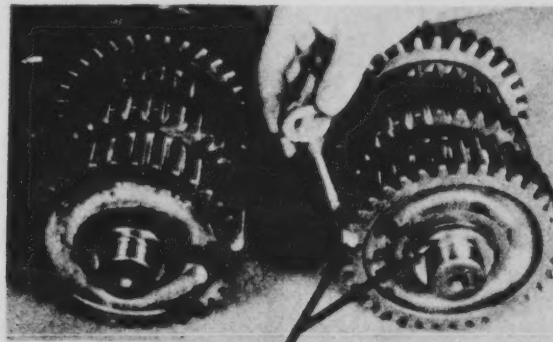
- N. Mark timing teeth on countershaft drive gears

1. Find tooth on drive gear aligned with keyway (Figure 13)

(NOTE: Timing tooth will have an "O" on the end of tooth.)

2. Paint complete timing tooth on each countershaft

FIGURE 13



JOB SHEET #4

- O. Place left and right countershafts in the case without bearings
- P. Assemble mainshaft
1. Place mainshaft in vise with keyway to the left or right and pilot end up
 2. Place key in keyway with word top to the outside and cross pin up
 3. Place reverse gears splined washer on shaft in groove at bottom of shaft and slide key in square notch in washer to lock washer
(NOTE: 1st, 2nd, and 3rd, speed gears splined washers are the same; 4th speed gear washer is smaller in diameter.)
 4. Install 1st-reverse sliding clutch
(NOTE: Slot in all sliding clutches will have to align with key.)
 5. Remove long key and install 1st speed gear splined washer on shaft in 2nd groove from the bottom then reinstall long key to lock washers (Figure 14)
 6. Place 1st speed gear on shaft over splined washer with clutching teeth down (Figure 15)

FIGURE 14

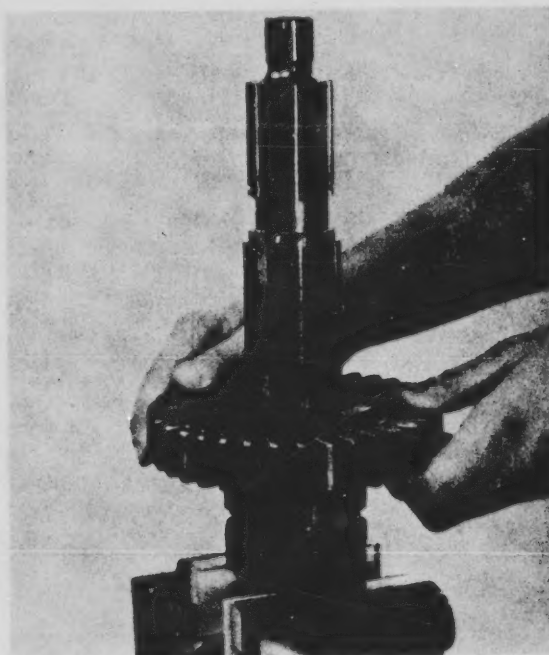
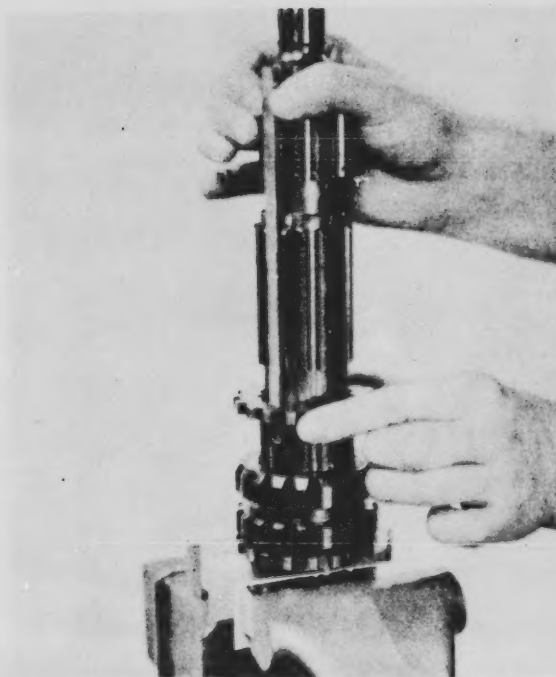


FIGURE 15

JOB SHEET #4

7. Install 2nd speed gear on shaft with clutching teeth up
8. Remove long key and install 2nd speed washer into hub of 2nd speed gear, then reinstall long key to lock all three washers (Figure 16)
9. Install 2nd-3rd speed sliding clutch
10. Pull long key up slightly and install 3rd speed washer at bottom of top groove, then move long key down and seat cross pin on top of 3rd speed washer (Figure 17)

FIGURE 16

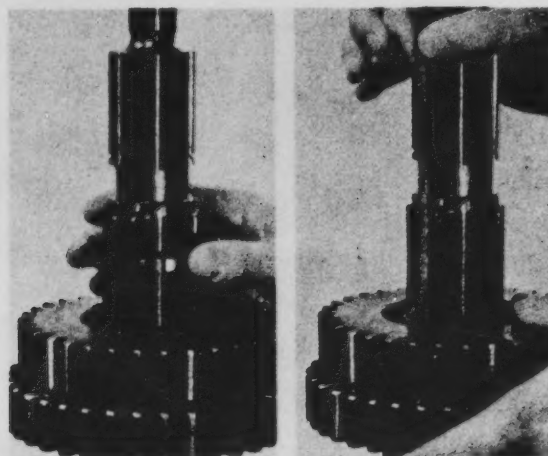


FIGURE 17



JOB SHEET #4

11. Install 3rd speed gear over splined washer
12. Install 4th speed gear on shaft with clutching teeth up
13. Install 4th speed washer on shaft inside 4th speed gear
14. Install snap ring in groove on shaft to hold 4th speed gear (Figure 18)
15. Install 4th-5th sliding clutch
16. Mark timing teeth on drive gear (Figure 19)

(NOTE: Mark any two adjacent teeth on gear then mark two teeth directly opposite the first set.)

FIGURE 18

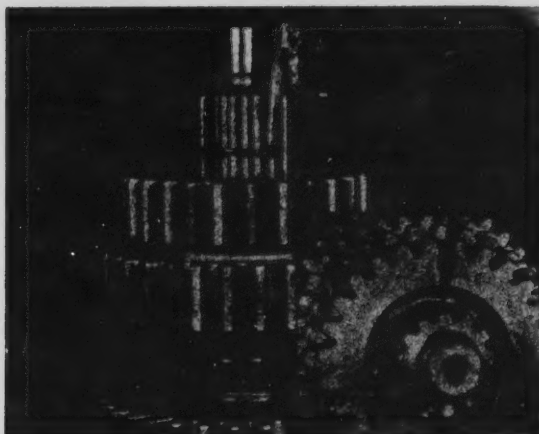
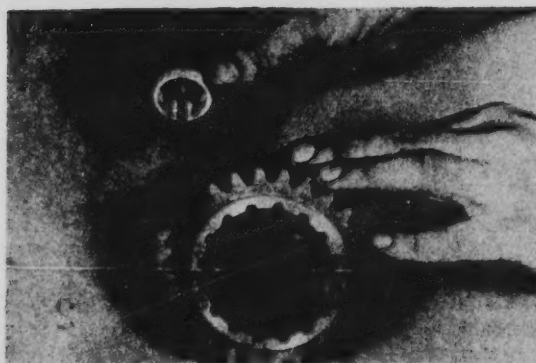


FIGURE 19



JOB SHEET #4

17. Install drive gear on shaft against 4th speed gear with snap ring groove to the front
 18. Remove mainshaft from vise and install reverse gear on rear of mainshaft over splined washer
- Q. Install mainshaft in case
1. Move both countershaft assemblies to side of case as far as possible
 2. Install mainshaft assembly in case and block under front to center shaft in bearing bore
- R. Assemble auxiliary drive gear and install in case
1. Press bearing on gear with snap ring toward rear
 2. Install bearing retaining snap ring in auxiliary drive gear groove (Figure 20)

FIGURE 20

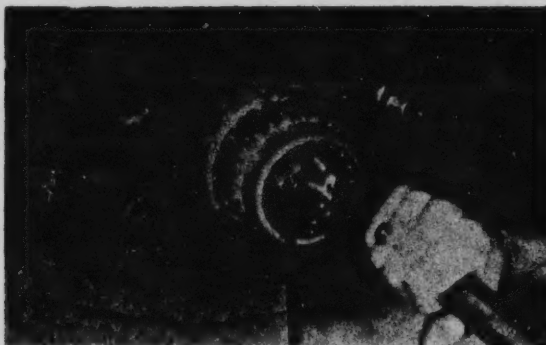


3. Center mainshaft in rear bearing bore
4. Install auxiliary drive gear and seat bearing in case

JOB SHEET #4

5. Install snap ring inside auxiliary drive gear and in groove in rear of mainshaft (Figure 21)

FIGURE 21



6. Install two bearing retainer plates and tighten capscrews
- S. Assemble clutch shaft and main drive gear
1. Replace pocket bushing clutch shaft
(NOTE: Make sure oil hole is not plugged and bushing is even with shaft.)
 2. Install clutch shaft inside main drive gear and move main drive gear forward against case
 3. Install snap ring in groove in main drive gear
 4. Install main drive gear spacer, taper forward
 5. Install clutch shaft bearing and seat in bore of case
 6. Install bearing retaining snap ring in groove on clutch shaft with taper to outside

JOB SHEET #4

- T. Time mainshaft to both countershafts and complete assembly of countershafts
1. Time left countershaft to mainshaft by placing one marked tooth on countershaft in mesh with two marked teeth on main drive gear (Figure 22)

FIGURE 22



2. Install front countershaft bearing part way while holding countershaft in position

(NOTE: Hold rear of countershaft centered in rear bearing bore with block of wood or tool.)
3. Install rear bearing and seat on countershaft and in case bore

(NOTE: Use bearing driver to prevent damage to bearing.)
4. Seat front bearing on shaft and in case bore
5. Install snap ring in groove in rear bearing bore
6. Time right countershaft to mainshaft by placing one marked tooth countershaft into mesh with two marked teeth on main drive gear
7. Hold right countershaft into position and install front and rear bearings in same way as left countershaft

JOB SHEET #4

U. Install left reverse idler gear

1. Install front washer on pin in case
2. Install bearing in gear
3. Install gear in case
4. Place rear washer and holder in case bore
5. Install left auxiliary countershaft bearing in case bore to hold idler gear in place

(NOTE: The front journal on auxiliary countershaft is used as a journal for reverse idler gear.)

V. Install clutch shaft bearing retainer and clutch housing

1. Place clutch shaft bearing retainer on clutch shaft and install and tighten capscrews
2. Place clutch housing on front of transmission case and install six nuts and two bolts

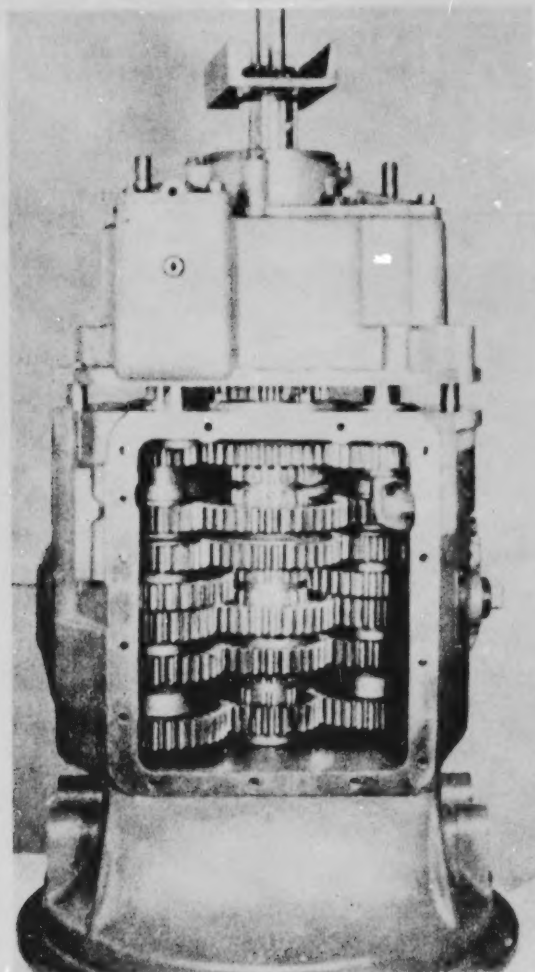
(NOTE: Use manufacturer's torque ratings on all nuts, capscrews, and bolts.)

JOB SHEET #4

W. Install auxiliary section to front section

1. Stand main transmission with clutch housing down (Figure 23)

FIGURE 23



2. Center reverse idler gears and washers in case bores

(NOTE: Washers and gears must be centered in case bores to allow front journals of countershafts to enter bearings of idler gears.)

3. Use chain hoist and lower auxiliary section onto front section (Figure 23)

(NOTE: Align auxiliary section on dowel pins in front section, and align auxiliary countershafts in bearings of idler gears.)

JOB SHEET #4

4. Install and torque auxiliary capscrews
 5. Install and torque output shaft flange or yoke
- X. Install shift bar housing
1. Place shift bars in neutral
 2. Place all sliding clutches on mainshaft in neutral
 3. Place shift bar housing on transmission (Figure 24)

(NOTE: Be sure that all yokes fit in yoke grooves on all sliding clutches.)

FIGURE 24



4. Install all capscrews and tighten

JOB SHEET #4

Y. Install range shift air valve

1. Install actuating pin and spring in bore of transmission case (Figure 25)

FIGURE 25



2. Install alignment sleeve in air valve

(NOTE: Piston in air valve has to be either all the way forward or all the way to the rear.)

3. Install bolt in valve and tighten

Z. Install air system lines

1. Install high range air line between the air port in the rear cover of the air cylinder and side rear port of air valve
2. Install the low range air line from airport in top of cylinder to street ell in top of the air valve side cap
3. Install air filter and regulator assembly on mounting surface on left rear of transmission case
4. Install air lines from output port of regulator and tee supply port of air valve then clamp line at rear left of gear shift lever mounting bolt
5. Install air lines from range shift valve to range shift control valve

MECHANICAL TRANSMISSIONS
UNIT IV

JOB SHEET #5--DISASSEMBLE A SHIFTING BAR HOUSING

I. Tools and materials

- A. Basic hand tool set
- B. Shop towels
- C. Solvent
- D. Work bench with vise
- E. Safety glasses

II. Procedure

A. Remove tension springs

- 1. Turn out two capscrews
- 2. Remove tension spring cover
- 3. Remove three tension springs

(CAUTION: Remove springs with care or springs and bearing balls will fly all over the place.)

B. Remove shift bars, shift yokes, interlock pin, and actuating plunger

- 1. Place housing in vise with plunger up and front of housing to the right
- 2. Cut lockwire on lockscrew in top shift yoke
- 3. Remove lockscrew
- 4. Remove top shift bar to right

(NOTE: Hold shift yokes while removing bars and keep all bars in neutral.)

- 5. Cut lockwire on lockscrew in center bar
- 6. Move center bar to right and out of shifting yoke, as neutral notch clears front web, remove interlock pin from bore in neutral notch
- 7. Remove actuating plunger
- 8. Move lower bar to right and remove shift yoke
- 9. Remove two interlocking balls from front web

MECHANICAL TRANSMISSIONS
UNIT IV

JOB SHEET #6--INSPECT A SHIFTING BAR HOUSING AND PARTS

- I. Tools and materials
 - A. Cleaning solvent
 - B. Shop towels
- II. Procedure
 - A. Inspect shift yokes and blocks
 - 1. Check yokes for wear at pads
 - 2. Check yokes for wear at lever slots
 - 3. Check yokes for alignment
 - 4. Check lockcrew threads for wear
 - B. Inspect shift bars for wear at neutral notches from interlock balls
(NOTE: Bars indented adjacent to neutral notch should be replaced.)
 - C. Inspect tension springs and balls
 - 1. Check springs for tension
 - 2. Check springs for cracks or breaks
 - 3. Check balls for flat spots

(NOTE: Replace all worn parts.)

MECHANICAL TRANSMISSIONS
UNIT IV

JOB SHEET #7--REASSEMBLE A SHIFTING BAR HOUSING

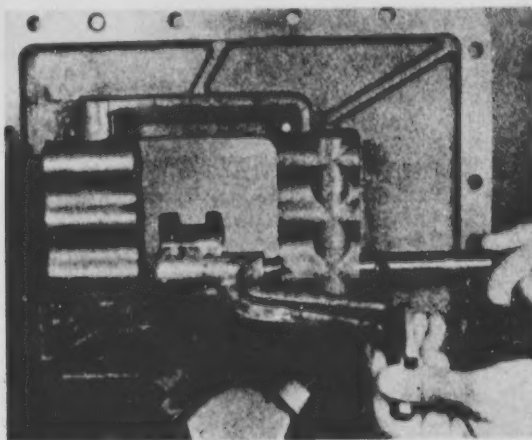
I. Tools and materials

- A. Lubricant
- B. Shop towels
- C. Basic hand tool set
- D. Vise
- E. Safety glasses

II. Procedure

- A. Place housing in vise with front to right (Figure 1)

FIGURE 1



B. Install 4th-5th shift bar and yoke

- 1. Install in bottom bore (Figure 1)
- 2. Install with neutral notches to front
- 3. Install yoke on bar with yoke toward front
- 4. Install lock screw and safety wire

JOB SHEET #7

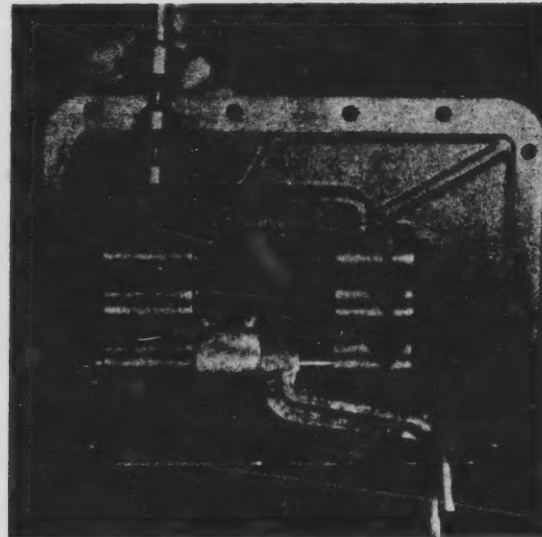
C. Install interlock ball and plunger

1. Install ball in bore in front web (Figure 2)
2. Install plunger in bore in rear web (Figure 3)

FIGURE 2



FIGURE 3



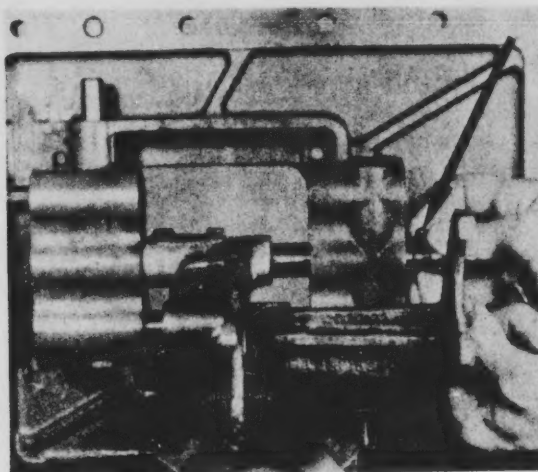
D. Install 2nd-3rd shift bar

1. Install in center bore
2. Install yoke on bar lockscrew hole to rear

JOB SHEET #7

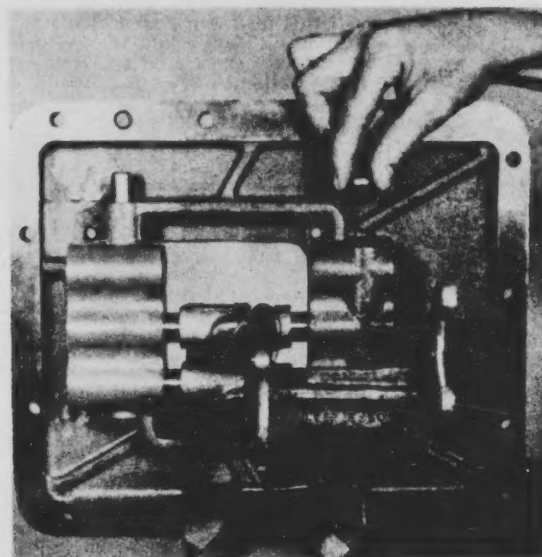
3. Insert interlock pin in bore in neutral notch (Figure 4)

FIGURE 4



4. Install yoke lockscrew and safety wire
5. Install interlock ball in bore in front web (Figure 5)

FIGURE 5

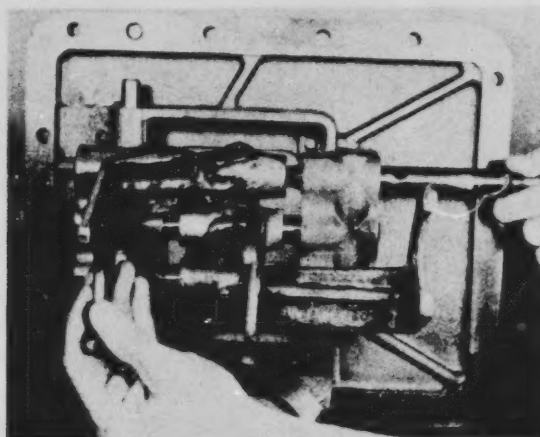


JOB SHEET #7

E. Install first reverse shift bar and yoke

1. Install in upper bore, neutral notches to front
2. Install yoke on bar, yoke to the rear (Figure 6)

FIGURE 6

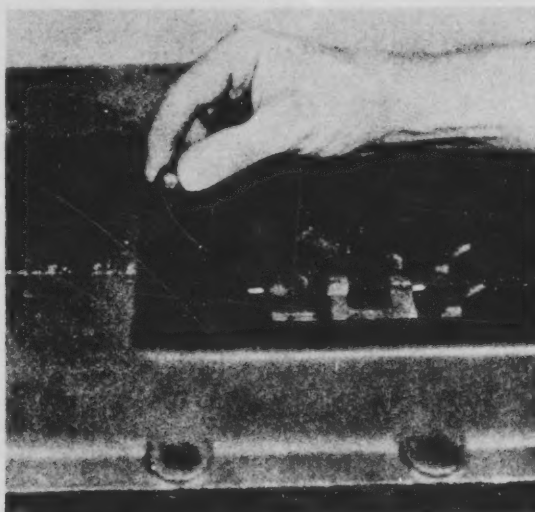


3. Install yoke lockscrew and safety wire

F. Install tension balls, springs, and spring cover

1. Remove housing from vise and place upright on bench
2. Place three balls in bores in housing (Figure 7)

FIGURE 7



JOB SHEET #7

3. Place three springs one on top of each ball
4. Install tension spring cover and tighten capscrews

MECHANICAL TRANSMISSIONS
UNIT IV

JOB SHEET #8--INSTALL A MECHANICAL TRANSMISSION

I. Tools and materials

- A. Safety glasses
- B. Basic hand tools
- C. Creeper
- D. Proper lubricant
- E. Chock blocks
- F. Transmission jack
- G. Alignment bolts

II. Procedure

A. Position transmission on jack

- 1. Place transmission on jack
- 2. Level transmission to same degree as engine
- 3. Secure transmission on jack to prevent falling off during installation

(CAUTION: Chock vehicle to prevent rolling.)

B. Position transmission under vehicle

- 1. Roll transmission under vehicle

(NOTE: Jack vehicle up if necessary to get transmission under vehicle.)

- 2. Jack transmission up to where clutchshaft lines up with hole in clutch

C. Install transmission to engine

- 1. Put transmission in gear
- 2. Move transmission forward to engine

(CAUTION: Make sure transmission and jack move as a unit so transmission does not slip off.)

(NOTE: While moving transmission forward, turn transmission output shaft so clutch shaft splines will line up with splines in clutch.)

JOB SHEET #8

3. Install two to four line up bolts in bell housing

(NOTE: Alignment bolts can be made of 4" to 6" bolts with hex heads cut off and slots cut in end for screwdriver to remove.)

(CAUTION: Be sure clutch forks engage clutch release bearing.)

4. Align clutch housing to bell housing when they are about 1" apart so there is equal distance between them at all points

(NOTE: Clutch housing and bell housing have to be in alignment so clutch shaft will enter pilot bearing.)

5. Continue pushing transmission forward until there is no space between clutch housing and bell housing

(CAUTION: Never use bolts or jack to force housing together or damage may result to pilot bearing, front transmission bearing, and clutch housing.)

6. Remove line up bolts

7. Install clutch to bell housing bolts and tighten

8. Install shift control

9. Hook up air lines (if used)

10. Hook up drive line universal joint to transmission yoke

(NOTE: Make sure drive line slip yoke is in time if used.)

11. Remove transmission jack

12. Fill transmission to proper level

(CAUTION: Make sure fill and drain plugs are tight in transmission case.)

MECHANICAL TRANSMISSIONS
UNIT IV

JOB SHEET #9-TEST A MECHANICAL TRANSMISSION AFTER REBUILDING

I. Tools and materials

- A. Creeper
- B. Shop towels
- C. Light
- D. Safety glasses

II. Procedure

A. Visual inspection before roadtest

- 1. Visually inspect all bolts for tightness, lockwashers, and proper installation
- 2. Visually inspect for lubricant leaks
- 3. Inspect for proper installation of driveline
- 4. Start engine to build up air pressure and check for air leaks in air shift system (if used)

B. Roadtest

- 1. Check clutch for proper operation
- 2. Listen for unusual noise

(NOTE: All transmissions make certain sounds which are normal. Through experience you learn to distinguish between normal and abnormal sounds.)

C. Visual inspection after roadtest

- 1. Check for lubricant leaks
- 2. Check for air leaks
- 3. Check for loose bolts

D. Check lubricant level in transmission

MECHANICAL TRANSMISSIONS
UNIT IV

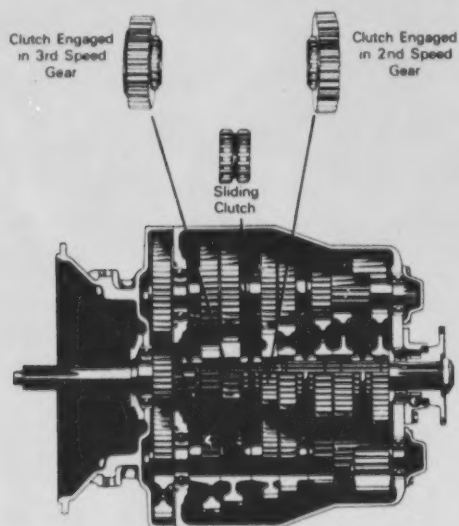
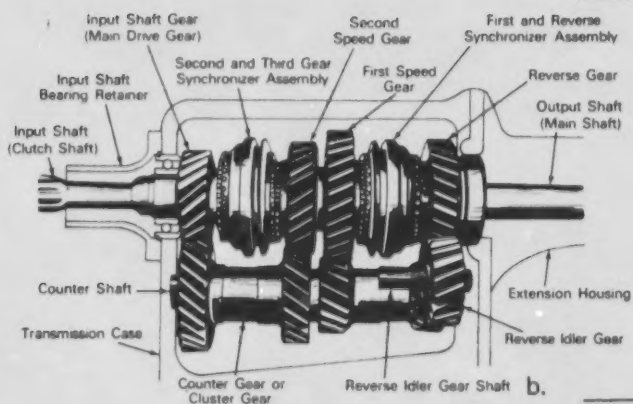
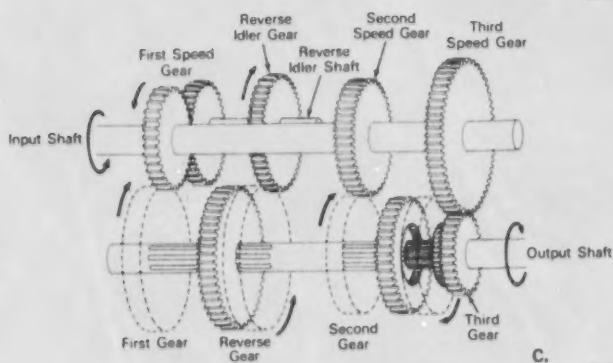
NAME _____

TEST

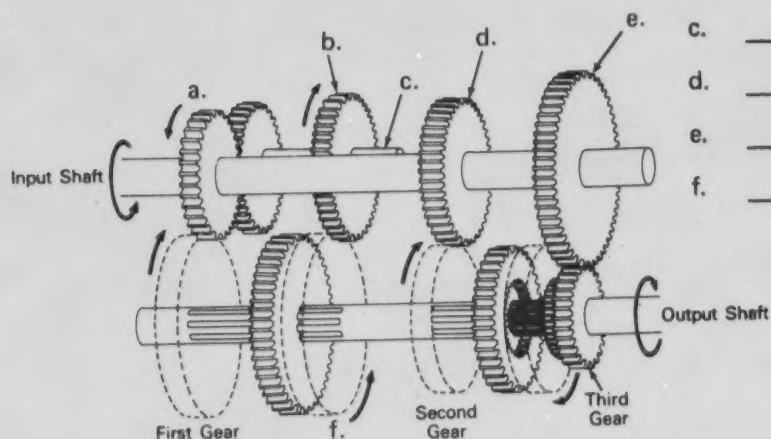
1. Match terms on the right with their correct definitions.

- | | |
|---|---------------------------|
| _____ a. Used to multiply engine torque and vary vehicle speed by means of gears arranged so that different ratios can be selected to meet various operating requirements | 1. Helical gears |
| _____ b. Gears with straight teeth | 2. Idler gear |
| _____ c. Gears with slanted teeth; usually found in constant mesh synchronized transmissions | 3. Gear ratio |
| _____ d. A transmission in which the gear ratio is less than one to one | 4. Overdrive transmission |
| _____ e. The number of revolutions the driving gear must make to turn the driven gear one revolution | 5. Spur gears |
| _____ f. Device in the transmission that allows two gears being shifted together to rotate at the same speed | 6. Transmission |
| _____ g. Gear in the transmission used to change direction of rotation of the output shaft | 7. Output shaft |
| _____ h. Timing assures that the countershaft gears will contact the mating mainshaft gears at the same time, allowing mainshaft gears to center on the mainshaft and equally divide the load | 8. Gear timing |
| _____ i. An intermediate shaft which receives motion from a main shaft and transmits it to a working part | 9. Input shaft |
| _____ j. A cylinder or cone-shaped part having teeth on one surface which mate with and engage the teeth of another part which is not concentric with it | 10. Synchronizer |
| _____ k. The shaft carrying the driving gear by which the power is applied to the transmission | 11. Countershaft |
| _____ l. The shaft or gear which delivers the power from a device to the rest of the power train | 12. Gear |

2. Identify types of mechanical transmissions.

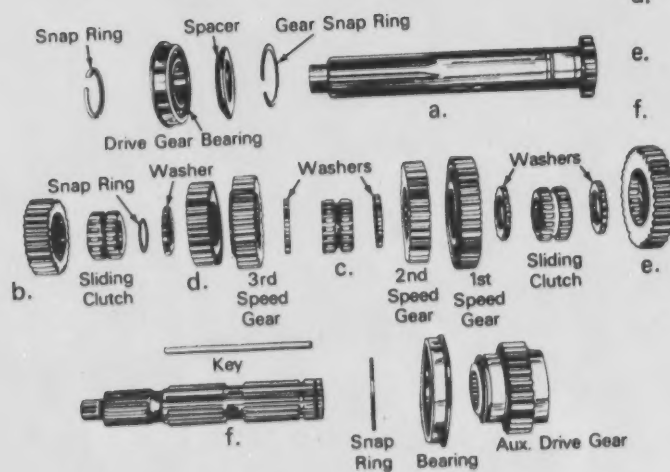
a. _____
_____b. _____
_____c. _____

3. Identify parts of a sliding gear transmission.



- a. _____
- b. _____
- c. _____
- d. _____
- e. _____
- f. _____

4. Identify parts of sliding clutch transmission top shaft.



- a. _____
- b. _____
- c. _____
- d. _____
- e. _____
- f. _____

5. Complete the following list of parts on a front section countershaft.

a. Woodruff key

b. Roll pin

c. Gear key

d. Snap ring

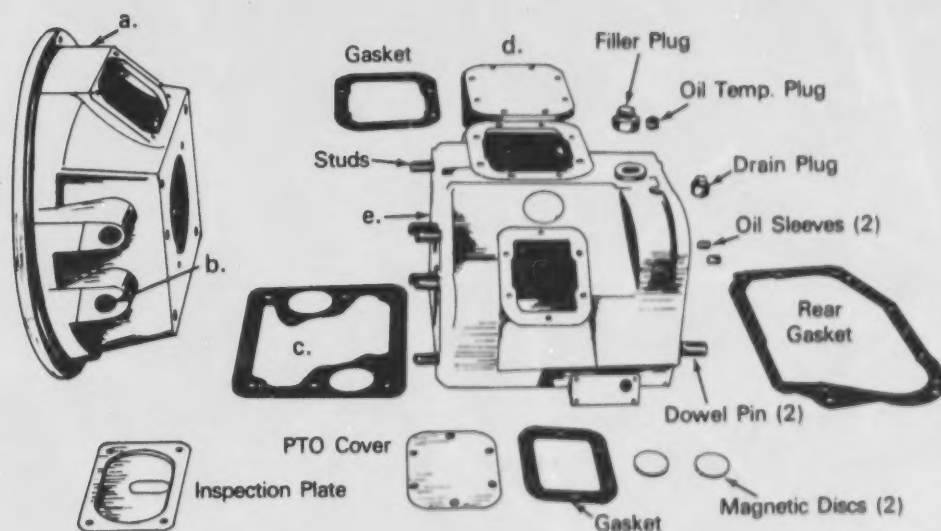
e. _____

f. _____

g. _____

h. _____

6. Identify parts of a transmission front section case with clutch housing.



a. _____

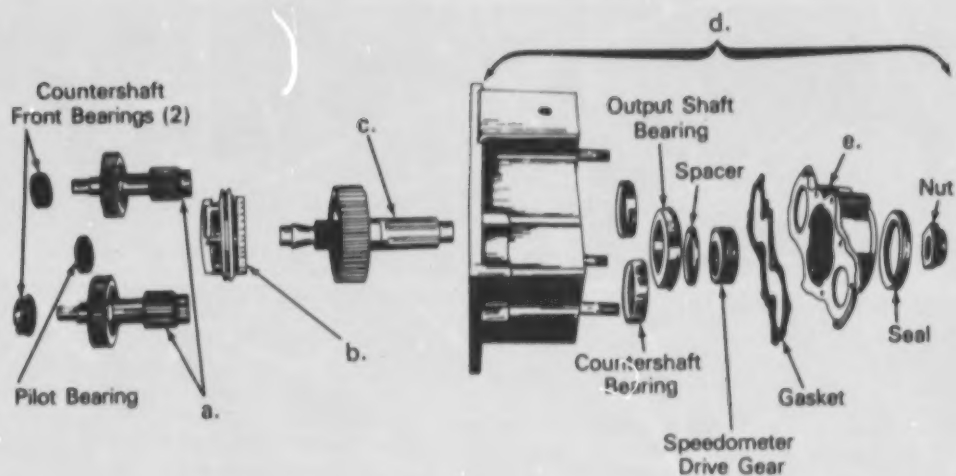
b. _____

c. _____

d. _____

e. _____

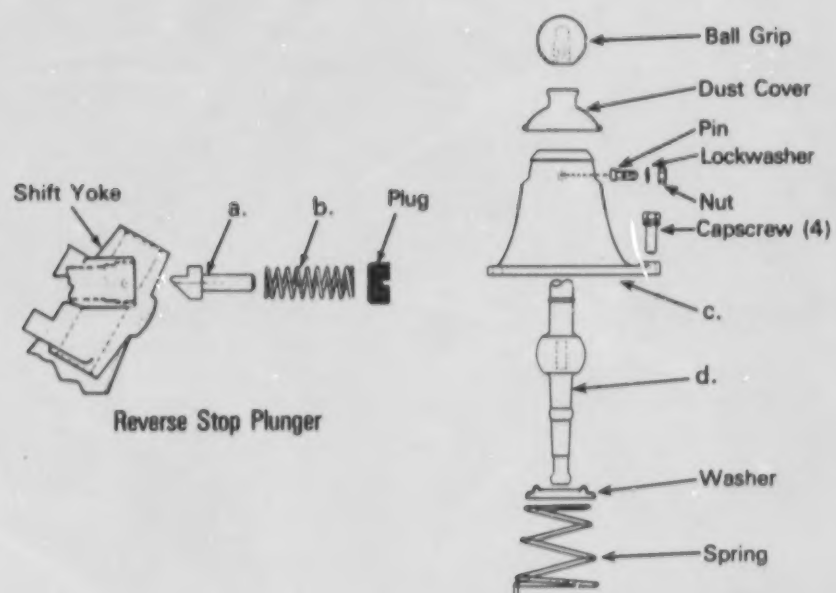
7. Identify parts of an auxiliary section of a ten speed transmission.



a. _____
b. _____
c. _____

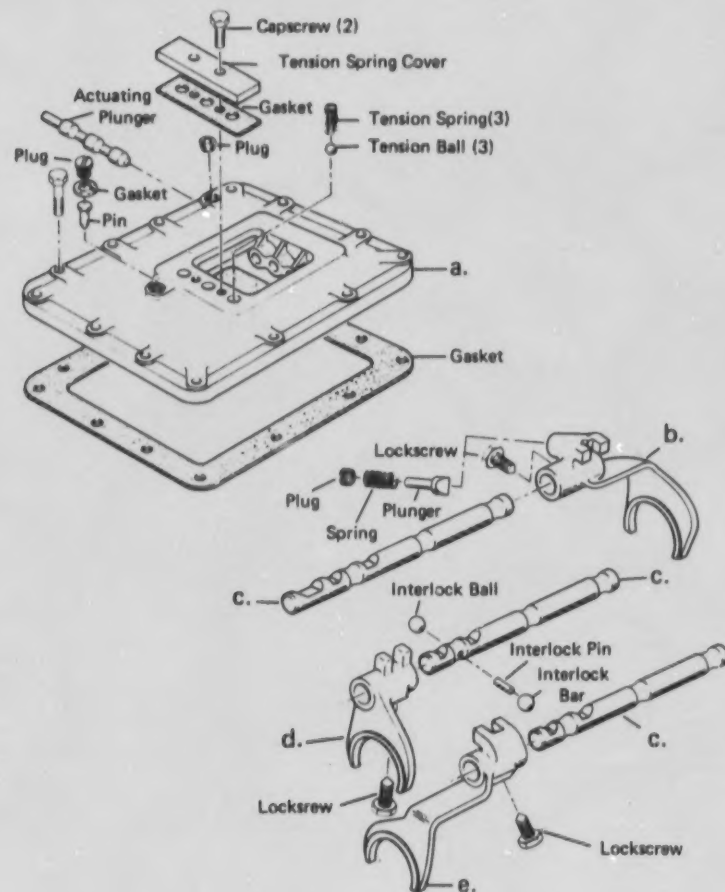
d. _____
e. _____
f. _____

8. Identify parts of a shift lever housing and reverse stop plunger.



- a. _____
- b. _____
- c. _____
- d. _____

9. Identify parts of a shift bar housing.



a. _____

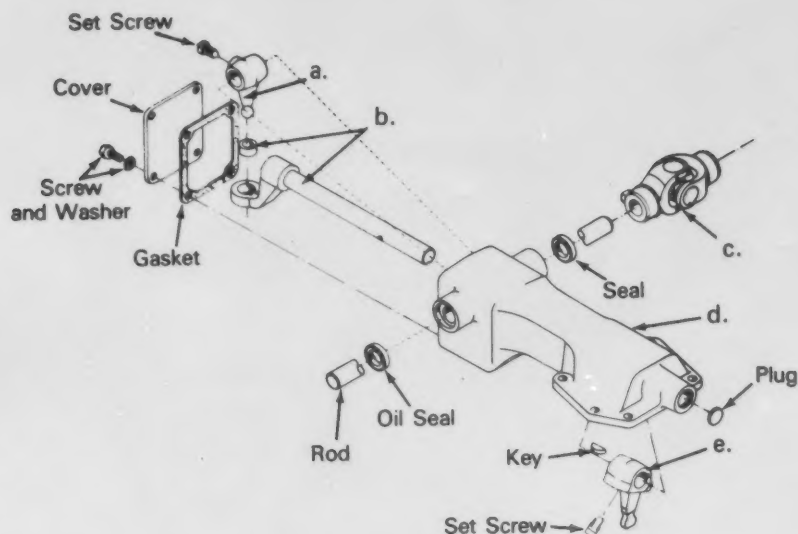
d. _____

b. _____

e. _____

c. _____

10. Identify parts of a remote shift control assembly.



- | | |
|----------|----------|
| a. _____ | d. _____ |
| b. _____ | e. _____ |
| c. _____ | |

11. Select true statements concerning air flow for range shifting by placing an "X" in the appropriate blanks.

- _____ a. Intermediate range-Air from slave air valve, side connection, to front of auxiliary shift cylinder
- _____ b. Low range-Air from slave air valve front connection to front connection of auxiliary shift cylinder, and from control valve F connection to small line connection on intermediate shift cylinder
- _____ c. Direct range-Air from slave air valve top connection to connection in rear of auxiliary shift cylinder and from control valve F connection to small connection on intermediate shift cylinder, and from control valve R connection to small front connection of slave air valve

12. Indicate air flow in air lines for range shifting.

13. Demonstrate the ability to:

- Check a mechanical transmission fluid level.
- Remove and disassemble a mechanical transmission.

- c. Inspect transmission parts.
- d. Reassemble a mechanical transmission.
- e. Disassemble a shifting bar housing.
- f. Inspect a shifting bar housing and parts.
- g. Reassemble a shifting bar housing.
- h. Install a mechanical transmission.
- i. Test a mechanical transmission after rebuilding.

(NOTE: If these activities have not been accomplished prior to test, ask your instructor when they should be completed.)

MECHANICAL TRANSMISSIONS
UNIT IV

ANSWERS TO TEST

- | | | | | | | |
|----|----|---|----|----|----|----|
| 1. | a. | 6 | e. | 3 | i. | 11 |
| | b. | 5 | f. | 10 | j. | 12 |
| | c. | 1 | g. | 2 | k. | 9 |
| | d. | 4 | h. | 8 | l. | 7 |
-
- 2. a. Sliding clutch
 - b. Synchromesh
 - c. Sliding gear
-
- 3. a. First speed gear
 - b. Reverse idler gear
 - c. Reverse idler shaft
 - d. Second speed gear
 - e. Third speed gear
 - f. Reverse gear
-
- 4. a. Clutch shaft
 - b. Drive gear
 - c. Sliding clutch
 - d. 4th speed gear
 - e. Reverse gear
 - f. Mainshaft
-
- 5. e. PTO and 2nd speed gear cluster
 - f. 3rd speed gear
 - g. 4th speed gear
 - h. Drive gear
-
- 6. a. Clutch housing
 - b. Clutch shaft bushing
 - c. Front gasket
 - d. PTO cover
 - e. Front section case
-
- 7. a. Auxiliary countershaft assemblies
 - b. Synchronizer assembly
 - c. Low speed gear and tailshaft assembly
 - d. Auxiliary housing and rear bearing assembly
 - e. Bearing and seal housing
-
- 8. a. Plunger
 - b. Spring
 - c. Housing
 - d. Gearshift lever

9.
 - a. Shift bar housing
 - b. 1st reverse shift yoke
 - c. Shift bars
 - d. 2nd-3rd speed shift yoke
 - e. 4th-5th speed shift yoke
10.
 - a. Finger outershaft
 - b. Rod and bracket assembly
 - c. U-Joint assembly
 - d. Remote housing
 - e. Finger innershaft
11. c
12. Evaluated to the satisfaction of the instructor
13. Performance skills evaluated to the satisfaction of the instructor

AUTOMATIC TRANSMISSIONS UNIT V

UNIT OBJECTIVE

After completion of this unit, the student should be able to identify major parts of an automatic transmission, explain the function of automatic transmission components, and list the make-ready procedure for automatic transmission overhaul. The student should also be able to remove an automatic transmission from a vehicle, disassemble the transmission into subassemblies; clean, inspect, and reassemble the subassemblies, and reinstall, road test, and adjust an automatic transmission. This knowledge will be evidenced by correctly performing the procedures outlined in the job sheets and by scoring 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms related to automatic transmissions with their correct definitions.
2. Identify the major parts of an automatic transmission.
3. Arrange in order the steps in an oil pump and regulating valve operation.
4. Select true statements concerning low range, high range, and reverse range functions in an automatic transmission.
5. Complete a list of statements concerning the characteristics of automatic transmission fluid.
6. Arrange in order the procedure for properly checking automatic transmission fluid.
7. Match in-vehicle transmission tests with their functions.
8. Identify parts of a planetary gear system.
9. Complete statements concerning planetary gear system operation.
10. Match speed, torque, and directional functions of an automatic transmission with ways they are accomplished.
11. Complete a list of tools and equipment required for automatic transmission overhaul.
12. Name three parts normally replaced at each automatic transmission overhaul.
13. Select true statements concerning important elements of cleaning and inspection.
14. Complete statements concerning special considerations for bearing inspection and handling.

15. Match other transmission components with their inspection requirements.
16. Arrange in order make-ready procedures for removing or installing an automatic transmission.
17. List three general rules for determining whether to reuse or replace a part.
18. Demonstrate the ability to:
 - a. Remove an automatic transmission from a vehicle.
 - b. Disassemble an automatic transmission into subassemblies.
 - c. Check end play on a torque converter assembly.
 - d. Disassemble, clean, and inspect a torque converter assembly.
 - e. Rebuild a stator assembly.
 - f. Reassemble a torque converter assembly.
 - g. Disassemble, clean, inspect, and reassemble a modulated lockup valve assembly.
 - h. Disassemble, clean, inspect, and reassemble a low shift valve assembly.
 - i. Disassemble, clean, inspect, and reassemble a control valve body assembly.
 - j. Disassemble, clean, inspect, and reassemble an oil pump and front support assembly.
 - k. Disassemble, clean, inspect, and reassemble a forward clutch and turbine shaft.
 - l. Disassemble, clean, inspect, and reassemble a fourth clutch.
 - m. Disassemble, clean, inspect, and reassemble a center support assembly.
 - n. Disassemble, clean, inspect, and reassemble a gear unit and main shaft assembly.
 - o. Disassemble, clean, inspect, and reassemble an output shaft.
 - p. Disassemble, clean, inspect, and reassemble a rear cover assembly.
 - q. Disassemble, clean, inspect, and reassemble an adapter housing and first clutch piston.
 - r. Disassemble, clean, inspect, and reassemble a transmission housing.
 - s. Reassemble an automatic transmission.
 - t. Install an automatic transmission.
 - u. Test an automatic transmission.
 - v. Make shift speed adjustments on an automatic transmission.

AUTOMATIC TRANSMISSIONS UNIT V

SUGGESTED ACTIVITIES

- I. Provide student with objective sheet.
- II. Provide student with information and job sheets.
- III. Make transparencies.
- IV. Discuss information sheet.
- V. Discuss and demonstrate the procedures outlined in the job sheets.
- VI. Have an up to date Detroit Diesel Allison *Transmission Service Manual* available for reference while the job sheets are being performed.
- VII. Have a safety director from an automatic transmission overhaul shop talk to the class about shop safety with special emphasis on using hoists and lifting slings, and the need for wearing safety glasses when cleaning or drying parts with compressed air.
- VIII. Arrange for a field trip to an industry that rebuilds or overhauls automatic transmissions, and have the students take notes and make brief reports about the procedures and safety practices they observe.
- IX. Have a planetary gear system available for display and demonstration in the classroom; explain how the gear functions in high, low, reverse, and direct drive.
- X. Show films of different types of automatic transmissions, and compare their overhaul requirements with the procedures contained in the job sheets in this unit.
- XI. Modify the job sheets in this unit as required to facilitate equipment and transmissions available in your shop, but be sure that any modifications reflect the total procedures with major parts and all subassemblies as presented in this unit.
- XII. Use charts or materials from a service manual to show students special disassembly and assembly tools recommended by various manufacturers and impress upon students the necessity of having special tools for disassembly and assembly procedures.
- XIII. Give test.

INSTRUCTIONAL MATERIALS

- I. Included in this unit:
 - A. Objective sheet
 - B. Information sheet

C. Transparency masters

1. TM 1--Major Parts of an Automatic Transmission
2. TM 2--Parts of an Oil Pump
3. TM 3--Oil Pump and Pressure Regulator
4. TM 4--Automatic Transmission in Low Range
5. TM 5--Automatic Transmission in High Range
6. TM 6--Automatic Transmission in Reverse Range
7. TM 7--Checking Transmission Fluid Level
8. TM 8--Parts of a Planetary Gear System

D. Job sheets

1. Job Sheet #1--Remove an Automatic Transmission From a Vehicle
2. Job Sheet #2--Disassemble an Automatic Transmission into Subassemblies
3. Job Sheet #3--Check End Play on a Torque Converter Assembly
4. Job Sheet #4--Disassemble, Clean, and Inspect a Torque Converter Assembly
5. Job Sheet #5--Rebuild a Stator Assembly
6. Job Sheet #6--Reassemble a Torque Converter Assembly
7. Job Sheet #7--Disassemble, Clean, Inspect, and Reassemble a Modulated Lockup Valve Assembly
8. Job Sheet #8--Disassemble, Clean, Inspect, and Reassemble a Low Shift Valve Assembly
9. Job Sheet #9--Disassemble, Clean, Inspect, and Reassemble a Control Valve Body Assembly
10. Job Sheet #10--Disassemble, Clean, Inspect, and Reassemble an Oil Pump and Front Support Assembly
11. Job Sheet #11--Disassemble, Clean, Inspect, and Reassemble a Forward Clutch and Turbine Shaft
12. Job Sheet #12--Disassemble, Clean, Inspect, and Reassemble a Fourth Clutch
13. Job Sheet #13--Disassemble, Clean, Inspect, and Reassemble a Center Support Assembly
14. Job Sheet #14--Disassemble, Clean, Inspect, and Reassemble a Gear Unit and Main Shaft Assembly

15. Job Sheet #15--Disassemble, Clean, Inspect, and Reassemble an Output Shaft
16. Job Sheet #16--Disassemble, Clean, Inspect, and Reassemble a Rear Cover Assembly
17. Job Sheet #17--Disassemble, Clean, Inspect, and Reassemble an Adapter Housing and First Clutch Piston
18. Job Sheet #18--Disassemble, Clean, Inspect, and Reassemble a Transmission Housing
19. Job Sheet #19--Reassemble an Automatic Transmission
20. Job Sheet #20--Install an Automatic Transmission
21. Job Sheet #21--Test an Automatic Transmission
22. Job Sheet #22--Make Shift Speed Adjustments on an Automatic Transmission

II. References:

- A. *Service Manual 3192 Marine Gear Transmission*. Peoria, IL: Caterpillar Tractor Co., 1962.
- B. Stockel, Martin W. *Auto Service and Repair*. South Holland, IL: The Goodheart-Wilcox Co., Inc., 1969.
- C. Notgrass, Troy. *The Automotive Power Train Mechanic*. Austin, TX: Instructional Materials Service Division of Extension, The University of Texas at Austin, 1973.
- D. Forier, Louis C. *Motor Trucks and Diesel Repair Manual*. 33rd Edition. New York, NY 10010: Motor, 1980.
- E. *1968 Ford Truck Shop Manual*. Dearborn, MI: Ford Service Publications, 1968.
- F. *Fundamentals of Service: Power Trains*. Moline, IL 61265: John Deere Service Publications, Dept. F, 1972.
- G. *Diagnosing Drive Train Noise and Vibration*. Chicago, IL 60611: International Harvester Co.
- H. *Service Manual: Detroit Diesel Allison Transmissions*. Detroit, MI 48228: Detroit Diesel Allison Division of General Motors Corporation, 1980.
- I. Dallas Independent School District. *Diesel Technology: Student Learning Plan*. New York, NY: Harper and Row Publishers, Inc., 1975.
- J. *1980 Car Shop Manual: Powertrain*. Dearborn, MI: Ford Service Publications, 1979.

AUTOMATIC TRANSMISSIONS UNIT V

INFORMATION SHEET

I. Terms and definitions

- A. Accumulator--A device used in automatic transmissions to cushion the shock of clutch and servo actions
- B. Automatic transmission--A transmission in which gear ratios are changed automatically
- C. Band--In an automatic transmission, a hydraulically controlled brake band installed around a metal clutch drum, used to stop or permit drum rotation
- D. Governor--A device used in certain automatic transmissions to control gear shifting in relation to vehicle speed
- E. Kickdown--A system in an automatic transmission which produces a downshift when the accelerator is pushed down to the floorboard
- F. Multiple-disc clutch--A clutch which has more than one friction disc; usually there are several driving discs and several driven discs, alternately placed
- G. Pressure regulator--A valve that opens to release oil from a line when the oil pressure attains specified maximum limits
- H. Servo--A device in a hydraulic system that converts hydraulic pressure into mechanical movement; it consists of a piston which moves in a cylinder as hydraulic pressure acts on it
- I. Shift valve--A valve that moves to produce the shifts from one gear ratio to another
- J. One-way clutch--A clutch in which power can be transmitted in one direction but not in the other
- K. Transmission oil cooler--A small radiator, mounted separately or as part of the engine radiator, to cool the transmission lubricating oil
- L. Wet-disc clutch--A clutch in which the friction disc (or discs) is operated in a bath of oil
- M. Viscosity--The resistance of a liquid to flow

Example: A thick oil has greater viscosity than a thin oil
- N. Vacuum modulator--A device in automatic transmissions that modulates, or changes, the mainline hydraulic pressure to meet changing engine loads

INFORMATION SHEET

- O. Planetary gear system--A gear-set consisting of a central sun gear surrounded by two or more planet pinions which are, in turn, meshed with a ring gear; used in overdrives and automatic transmissions
 - P. Power shift--A transmission designed to provide high speed by the use of hydraulic actuated clutches operated manually
- II. Major parts of an automatic transmission (Transparency 1)
- A. Lockup clutch
 - B. Torque converter
 - C. Forward clutch
 - D. Fourth clutch
 - E. Third clutch
 - F. Second clutch
 - G. Center planetary
 - H. First clutch
 - I. Low clutch
 - J. Output shaft
 - K. Low planetary
 - L. Rear planetary
 - M. Connecting drum
 - N. Front planetary
 - O. Sun gear shaft
 - P. Main shaft
 - Q. Turbine shaft
- III. Oil pump and pressure regulating valve operation (Transparency 2)
- A. The hub of converter pump fits into notches of oil pump and driving oil pump when engine is running
 - B. The oil pump is of the gear type, and the crescent is part of the pump housing (Transparency 3)
 - C. When the inner gear is turned by the converter hub the outer gear also turns

INFORMATION SHEET

- D. As the teeth of the two gears move apart oil is drawn in through an oil cavity (Transparency 3)
 - E. As the oil in the teeth of the gears is carried around to other side of crescent, the teeth come together, pressure is created, and the oil is forced out the pressure cavity (Transparency 3)
 - F. The oil pump can create low flow at low speed and high flow at high speed, so a pressure regulating valve is used to keep pump from building to high flow (Transparency 3)
 - G. The valve is usually of the spool type and, when there is no pressure on valve, the spring pushes the valve to the bottom of its bore
 - H. While engine is running, the pump directs the oil to the pressure regulator valve, then the oil comes in around the lands of the spool
 - I. As the oil flows through the pressure line, a small amount flows through an orifice under the valve
 - J. As pressure is built up, the valve rises and one band will uncover the passage leading to the return line, and this prevents the pressure from getting too high
- IV. Low range, high range, and reverse range functions in an automatic transmission
- A. Low range (Transparency 4)
 - 1. The engine turns the torque converter, which turns the transmission pump and input shaft
 - 2. Low band is applied either manually or by hydraulic pressure
 - 3. When the low band is applied the clutch drum and low sun gear are held stationary
 - 4. The input sun gear is turning in the same rotation as the engine
 - 5. The input sun gear is in mesh with the long pinion gears, which are in mesh with the short pinion gears
 - 6. As the short pinion gears walk around the ring gear, the output shaft is connected to the planetary-pinion carrier, which is rotating with the planet gears

(NOTE: Gear reduction is achieved in the combination of the short and long pinions.)
 - B. High range (Transparency 5)
 - 1. Engine turns torque converter, which turns oil pump and input shaft
 - 2. The low band is released in high range

INFORMATION SHEET

3. The forward clutch is applied which locks the sun gear to the input shaft
4. The whole planetary gear system turns as a unit

(NOTE: There is no gear reduction in the transmission.)

C. Reverse range (Transparency 6)

1. Engine supplies power to the torque converter, which turns oil pump and input shaft
2. The low band and forward clutch are released
3. The reverse clutch is applied either manually or by hydraulic pressure
4. The reverse ring gear is held stationary, and the sun gear turns the planet gears in the opposite directions (reverse)
5. Since the planet carrier is attached to the planet gears, it is turning the same direction as the planet gears
6. The output shaft is attached to the planet carrier which is turning in reverse

(NOTE: There is a gear reduction in reverse because of small planet gears turning around ring gear.)

V. Characteristics of automatic transmission fluid

(NOTE: It is very important to use the correct transmission fluid that is recommended by the transmission manufacturer.)

A. Automatic transmission fluid has several additives, such as:

1. Viscosity-index improver
2. Oxidation and corrosion inhibitors
3. Extreme-pressure and antifoam agents
4. Detergents
5. Dispersants
6. Friction modifiers
7. Pour point depressants
8. Fluidity modifiers

INFORMATION SHEET

- B. The red dye is added to fluid so it will not be confused with any other lubricants
- C. Do not use a fluid that is not recommended by manufacturer because it could cause serious damage to transmission

VI. Procedure for properly checking automatic transmission fluid (Transparency 7)

- A. Block wheels and apply parking brake
- B. Operate engine until transmission fluid is at normal operating temperature
- C. Shift transmission through all ranges at idle speed
- D. Leave engine idling and shift transmission into the recommended position
- E. Clean all dirt from around dipstick and cap
- F. Pull out and wipe dipstick; reinsert until cap bottoms on filler tube
- G. Pull dipstick and check if level is between arrows or Full and Add marks; adjust fluid level as necessary

(CAUTION: Do not over fill the transmission.)

VII. In-vehicle transmission tests and their functions

- A. Road test--Warms up transmission fluid to operating temperature, and indicates overall characteristics of transmission operation
- B. Stall test--Indicates the condition of torque converter operation and strength of hydraulic system
- C. Fluid pressure test--Tests each hydraulic circuit and compares it with manufacturer's specifications to detect general problems in hydraulic components
- D. Air pressure test--Tests each hydraulic component individually for pressure leaks

VIII. Parts of a planetary gear system (Transparency 8)

- A. Sun gear
- B. Planet pinion (gears)
- C. Ring gear (internal)
- D. Planet-pinion carrier and shaft
- E. Sun-gear shaft
- F. Tube to ring gear

INFORMATION SHEET

- IX. Planetary-gear system operation
 - A. A planetary gear system can act as a speed increaser and a torque reducer
 - B. The planetary gear system also can act as a speed reducer and a torque increaser
 - C. The planetary system can also act as a means to reverse flow of power
 - D. To get different speeds and different torques and reverse is made possible by applying the input rotation to different gears and holding one of the other two gears stationary
- X. Speed, torque, and directional functions of an automatic transmission and ways they are accomplished
 - A. Speed increased--torque reduced
 - 1. If the sun gear is held stationary and the planet-pinion carrier turns, there is a speed increase at the ring gear
 - 2. If the ring gear is held stationary and the planet-pinion carrier turns, there is a speed increase at the sun gear
 - B. Speed reduced--torque increased
 - 1. If the sun gear is held stationary and the ring gear turns, there is a speed reduction in the rotation of the planet-pinion carrier
 - 2. If the ring gear is held stationary and the sun gear turns, the planet-pinion carrier turns in the same direction as sun gear but at a slower speed
 - C. Reverse
 - 1. If the planet-pinion carrier is held stationary and the ring gear turns, the planet-pinion acts as an idler gear and turns sun gear in opposite rotation of ring gear
 - 2. If the planet-pinion carrier is held stationary and the sun gear turns, the planet-pinion acts as an idler gear and turns the ring gear in opposite rotation of sun gear
 - D. Direct drive--If any two of the three members (sun gear, carrier, or ring gear) are locked together, the whole planetary gear system is locked out and the input and output shaft turn at the same speed
- XI. Tools and equipment required for automatic transmission overhaul
 - A. 1500-pound capacity work table
 - B. Special tools as recommended by manufacturer in service manual

INFORMATION SHEET

C. Common mechanic's tools and shop equipment

1. Snapping pliers
2. Micrometer
3. 3-leg lifting sling of 1/2 ton capacity with 90° angle attaching plates
4. 1/2 ton capacity hoist (safety inspected)
5. Container of volatile mineral spirits for cleaning parts
(CAUTION: Caustic cleaning compounds will damage some transmission parts.)
6. Torque wrenches: 100-inch pound, 100-foot pound, and 1000-foot pound
7. Hot plate or heating equipment for heating bearings or other interference-fit parts to aid assembly
8. Clean, lint-free shop cloths
9. Boxes, receptacles for parts
10. Supply of wood blocks
11. Oil-soluble grease (petrolatum)
12. Nonhardening sealer, Peratex No. 2 or equivalent
13. Crocus cloth

(NOTE: Crocus cloth is sometimes called "emery" cloth, but the two should not be confused; crocus cloth contains iron oxide which is lightly abrasive and has high polishing characteristics; emery cloth contains a coarser variety of corundum and is used for grinding as well as polishing.)

14. Soft honing stone

XII. Parts normally replaced at each automatic transmission overhaul

- A. Gaskets
- B. Lockstrips
- C. Washers or springs damaged by removal
- D. Oil seals and piston sealrings

(CAUTION: Do not burn discarded Teflon seals; toxic gases are produced by burning.)

INFORMATION SHEET

XIII. Important elements of cleaning and inspection

- A. All parts must be clean to permit effective inspection

(NOTE: At reassembly, it is very important that no dirt or foreign matter be allowed to enter the transmission; even minute particles can cause the malfunction of close-fit parts such as valves.)

- B. All the metallic parts of the transmission, except bearings and friction-faced clutch plates, should be thoroughly cleaned with volatile mineral spirits or by steam cleaning

- C. Parts should be dried with compressed air

(CAUTION: When using compressed air for cleaning or drying, ALWAYS WEAR SAFETY GLASSES.)

- D. Steam-cleaned parts should be oiled immediately after drying

- E. Oil passages should be cleaned by working a piece of soft wire back and forth through the passages and flushing with mineral spirits, then drying with compressed air

- F. Examine all parts, especially oil passages, after cleaning to make certain they are entirely clean

XIV. Special considerations for bearing inspection and handling

- A. Inspect bearings for roughness of rotation; replace bearing if rotation is still rough after cleaning and oiling

- B. Inspect bearings for scored, pitted, scratched, cracked, or chipped races, and for excessive wear of rollers or balls; if any one of these defects is found, replace the bearings

- C. Inspect bearing housing and shaft for grooved, burred, or galled conditions that would indicate the bearing had been turning in the bore or on the shaft

(NOTE: If damage cannot be repaired with crocus cloth, replace the defective part.)

- D. Do not remove the wrapper from new bearings until ready to install them

- E. Do not remove the grease in which new bearings are packed

- F. Do not lay bearings on a dirty bench; place them on clean, lint-free cloths or paper

- G. If assembly is not to be completed at once, wrap or cover the exposed bearings with clean paper or lint-free cloth to keep dust out

INFORMATION SHEET

XV. Other transmission components and their inspection requirements

- A. Cast parts, machined surfaces--Inspect bores for wear, scratches, grooves, and dirt
- B. Oil passages--Inspect for obstructions
- C. Mounting faces--Inspect for nicks, burrs, scratches, and foreign matter
- D. Threaded openings--Inspect for damaged threads
- E. Bushings--Inspect for scores, burrs, roundness, sharp edges, and evidence of overheating
- F. Thrust washers--Inspect for distortion, scores, burrs, and wear
- G. Oil seals and gaskets--Inspect sealrings for cuts and hardness; replace all composition gaskets
- H. Gears--Inspect for scuffed, nicked, burred, or broken teeth; inspect thrust face for scores, scratches, and burrs
- I. Splined parts--Inspect for stripped, twisted, chipped, or burred splines
- J. Snaprings--Inspect for nicks, distortion, and excessive wear
- K. Springs--Inspect for signs of overheating, permanent set, or wear due to rubbing against adjacent parts

(NOTE: When springs require replacement, the manufacturer's spring chart should be used to select a proper replacement.)
- L. Clutch plates--Inspect friction-faced steel plates for burrs, embedded metal particles, severely pitted faces, excessive wear, cone, cracks, distortion, and damaged spline teeth; inspect steel plates for burrs, scoring, excessive wear, cone, distortion, embedded metal, galling, cracks, breaks, and damaged tangs
- M. Swaged, interference-fit parts--Inspect for looseness due to relative motion
- N. Balls in clutch housing--Inspect for restrictions to free movement
- O. Seal contact surfaces--Inspect for roughness, scoring, pitting, or wear that will either permit oil leakage or cause damage to the seal

XVI. Make-ready procedures for removing or installing an automatic transmission

- A. Drain the oil from the transmission before removing the transmission from the vehicle

(NOTE: For better drainage, the transmission should be warm and allowed to drain overnight; since applications will differ, consult the service manual before removing or reinstalling a transmission.)

INFORMATION SHEET

- B. Make sure that all linkages, controls, cooler lines, modulator actuator cable, temperature connection, input and output couplings, and mounting bolts are disconnected before transmission removal, also the oil filler tube and other equipment such as attached parking brake handle
- C. Place oil lines safely out of the way of damage and cover all oil line openings to keep dirt out
- D. Place jack or hoist sling relative to transmission center of gravity
- E. Install a retaining strap to hold the converter in place as soon as the transmission is clear of its mountings

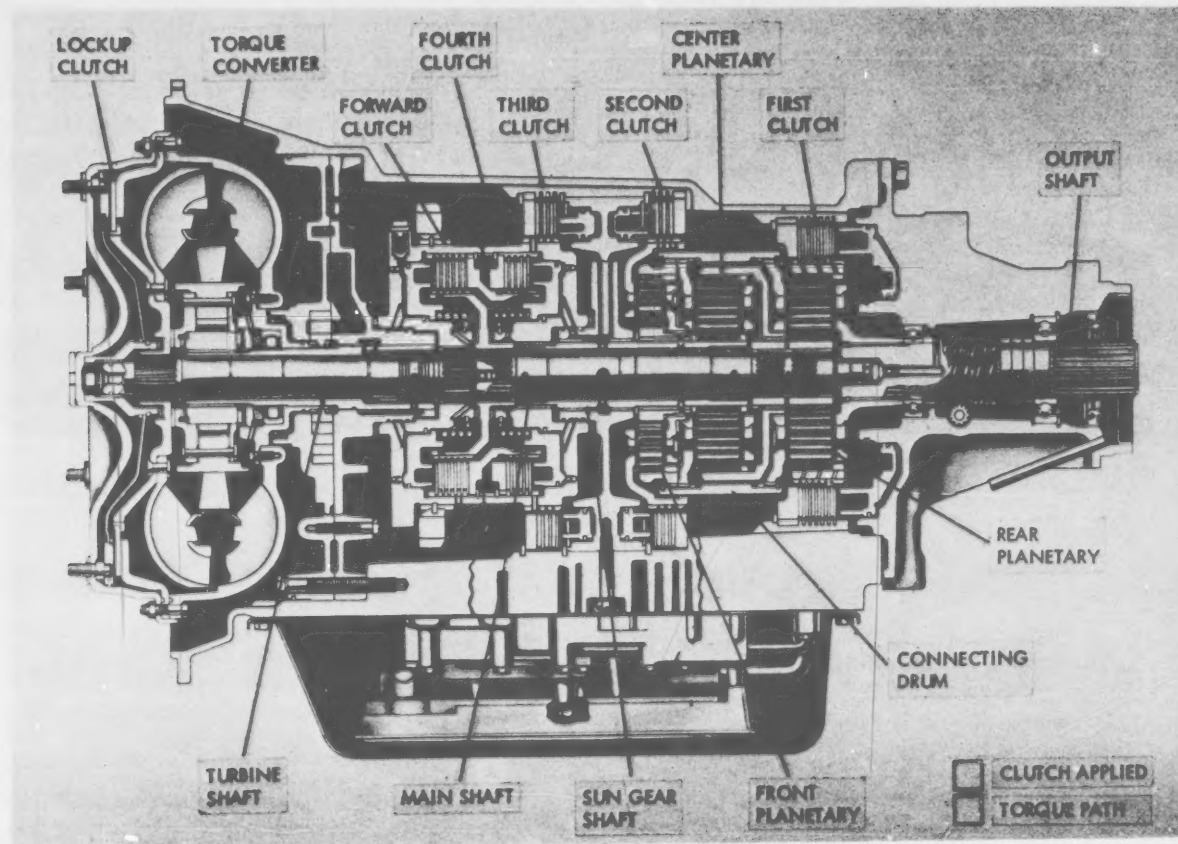
(NOTE: The torque converter is free to move forward when the transmission is disconnected from the engine.)
- F. Clean the exterior of the transmission

(CAUTION: Steam cleaning should be followed immediately by disassembly, because condensation allowed to remain in the transmission could cause rust.)
- G. At reinstallation, all items should be reconnected; a transmission jack is convenient to raise the transmission into mounting position
- H. Fill the transmission with oil
- I. Road test the transmission after installation

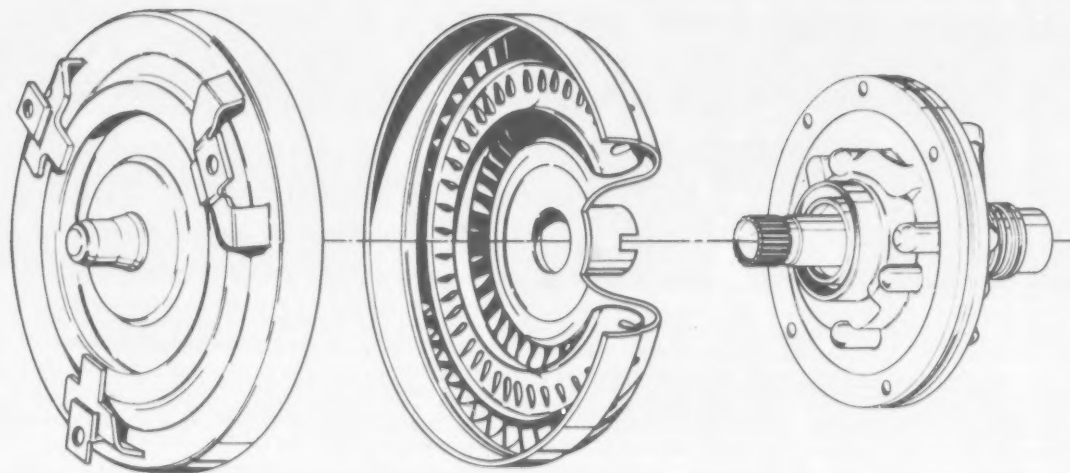
XVII. General rules for determining whether to reuse or replace a part

- A. Minor surface irregularities can usually be corrected with a crocus cloth and the part can be reused
- B. Some nicks, scuffs, and burrs can be corrected with a soft honing stone and the part can be reused
- C. Parts that cannot be smoothed or corrected with crocus cloth or a soft honing stone or parts that are obviously distorted or excessively worn should be replaced

Basic Parts of an Automatic Transmission



Parts of an Oil Pump

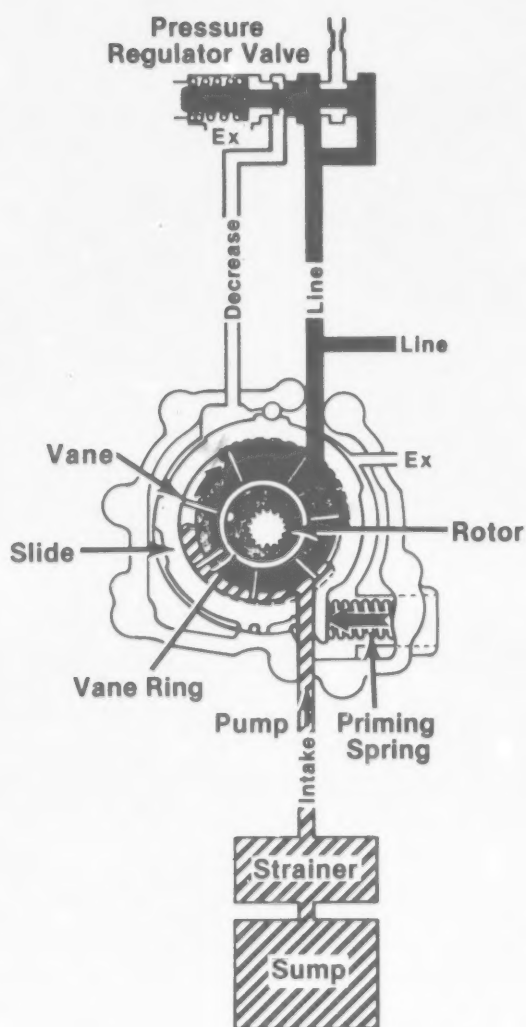


**Converter
Cover**

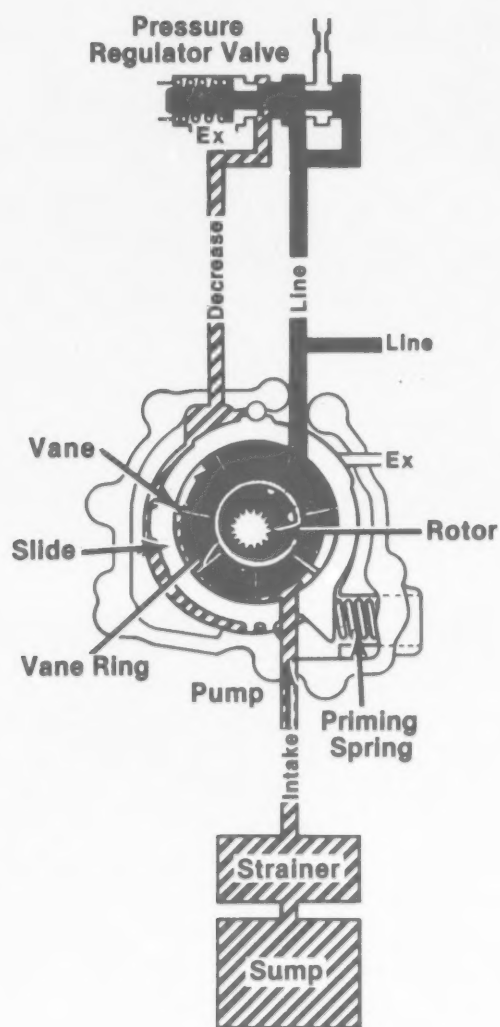
**Converter
Pump**

**Oil Pump
Assembly**

Oil Pump and Pressure Regulator



Maximum Pump Output



Minimum Pump Output

Courtesy General Motors Corporation

TM 3

Clutch Drum and Low Sun Gear Held Stationary

Reverse Ring Gear

Input Sun Gear

Output Shaft

Planet Carrier

Reverse Clutch

Long Pinion

Short Pinion

Forward Clutch

Low Band

Low Band Applied

Forward Clutch Released

Turbine

Stator Shaft

Input Shaft

Stator

Roller Clutch

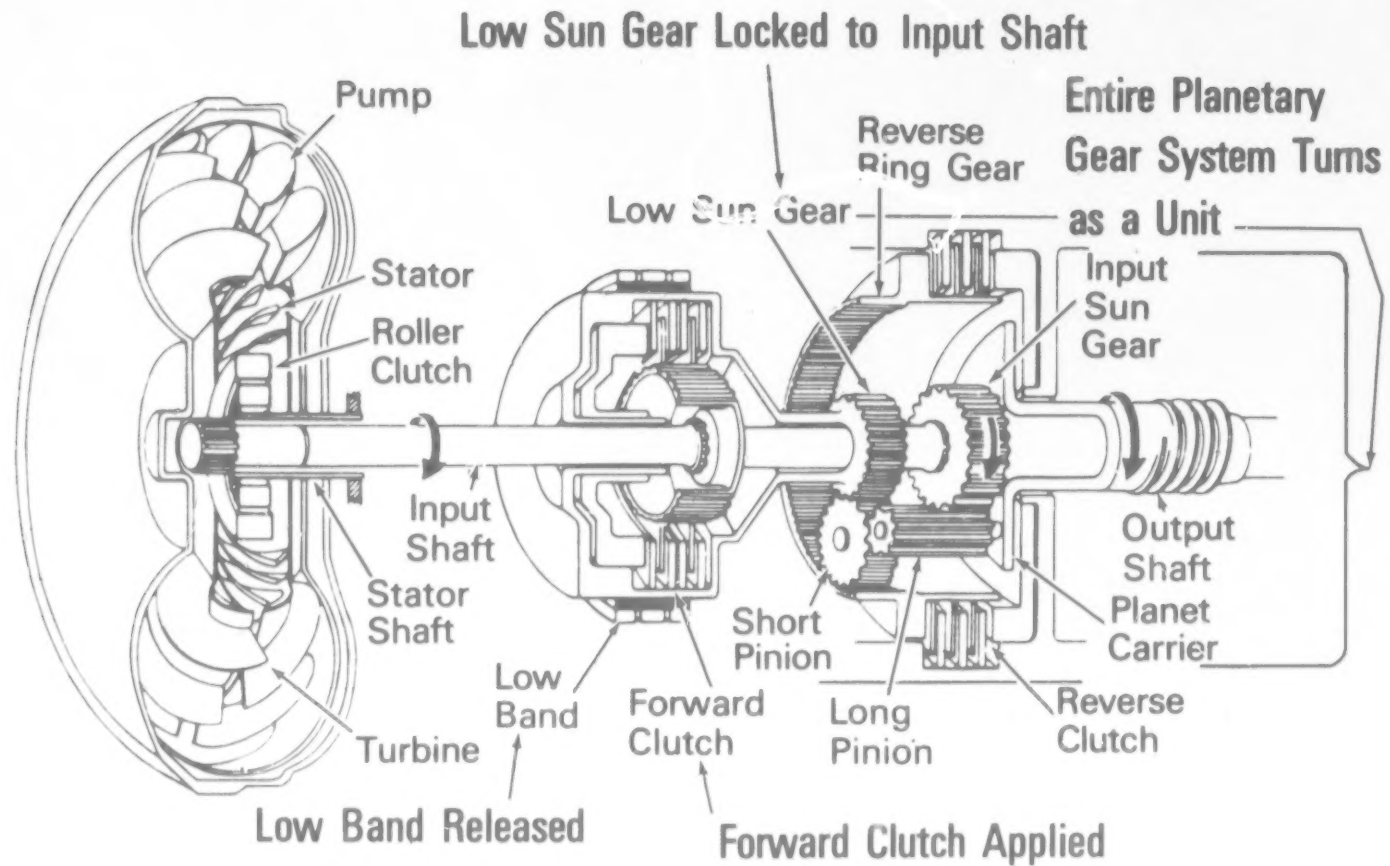
Clutch Drum

Low Sun Gear

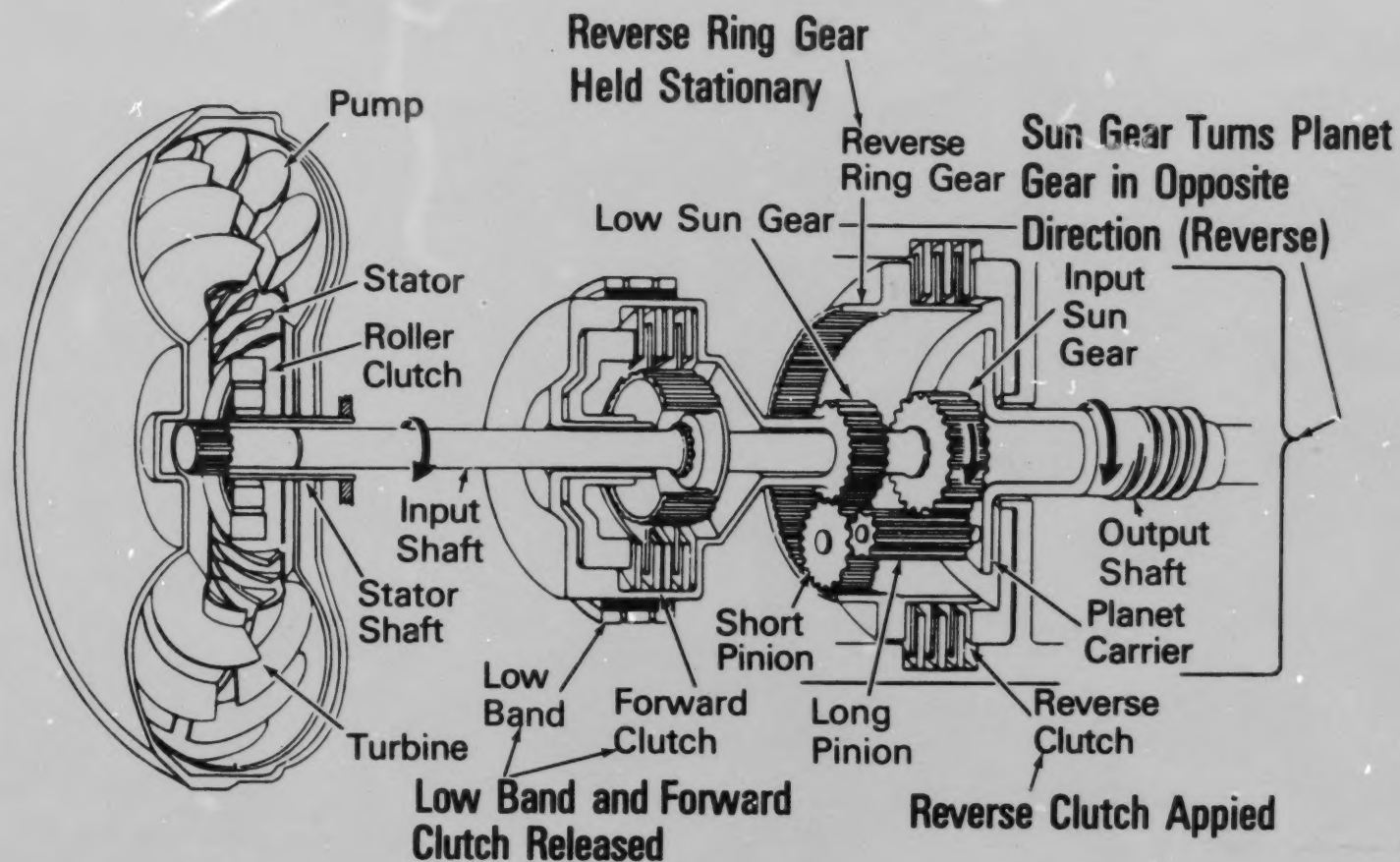
Pump

TM 4

Automatic Transmission in High Range

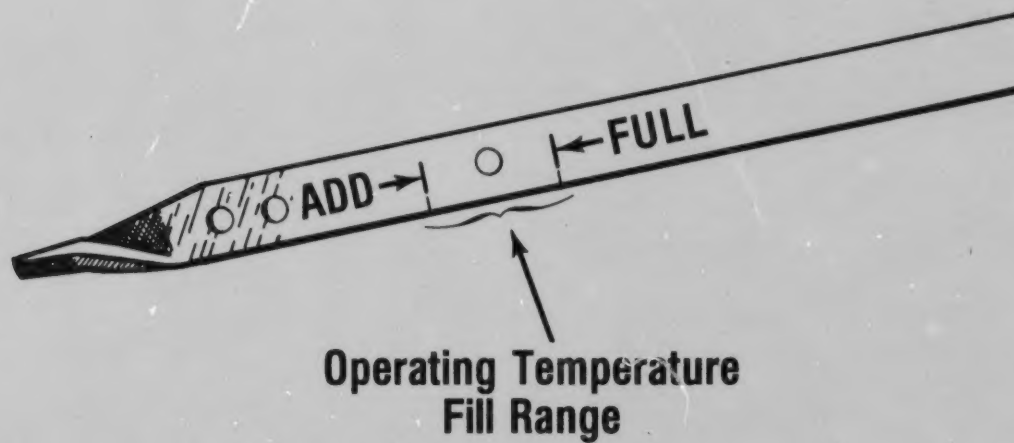


Automatic Transmission in Reverse Range

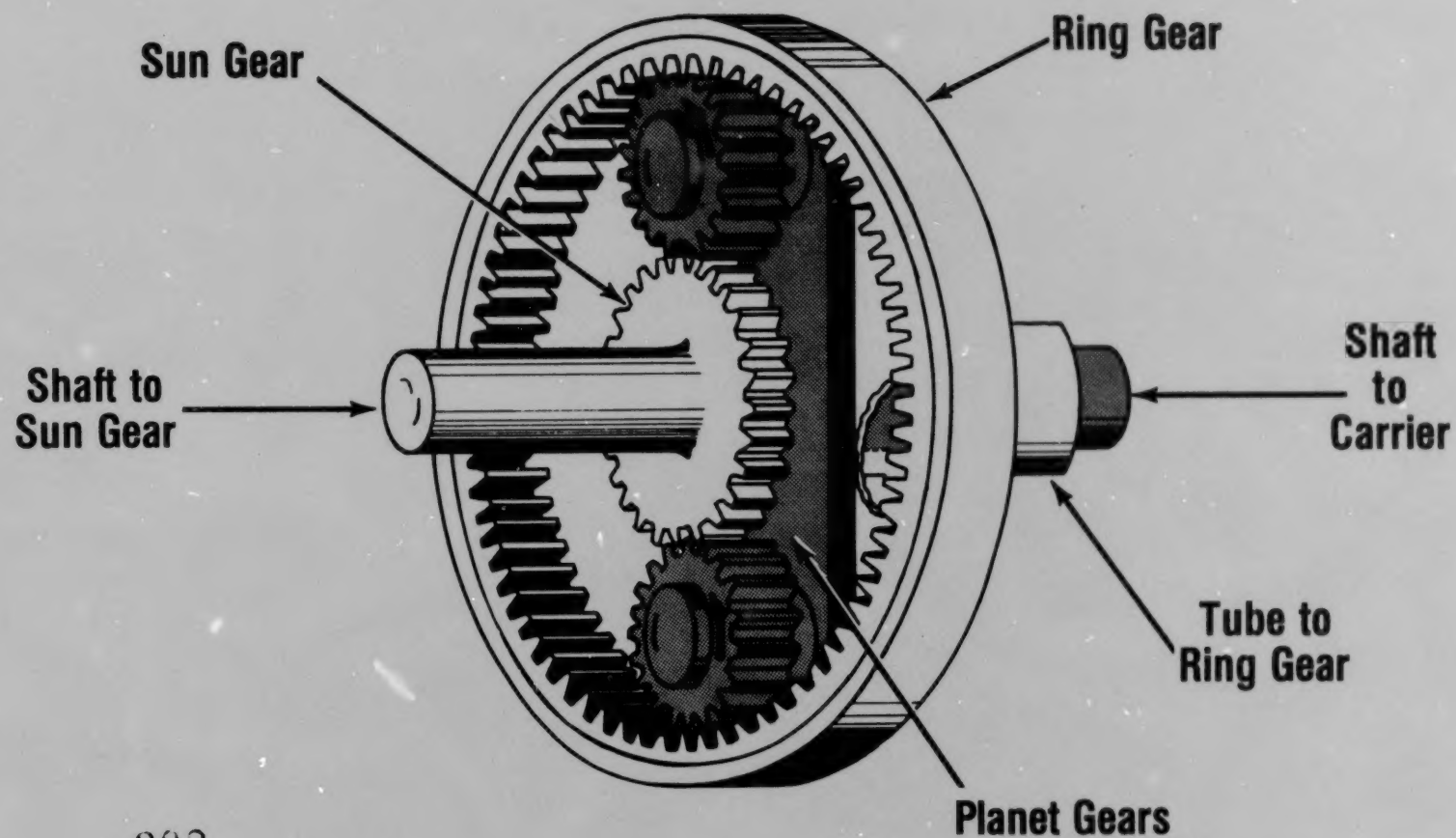


Courtesy General Motors Corporation

Checking Transmission Fluid Level



Parts of a Planetary Gear System



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AUTOMATIC TRANSMISSIONS
UNIT V

JOB SHEET #1--REMOVE AN AUTOMATIC TRANSMISSION FROM A VEHICLE

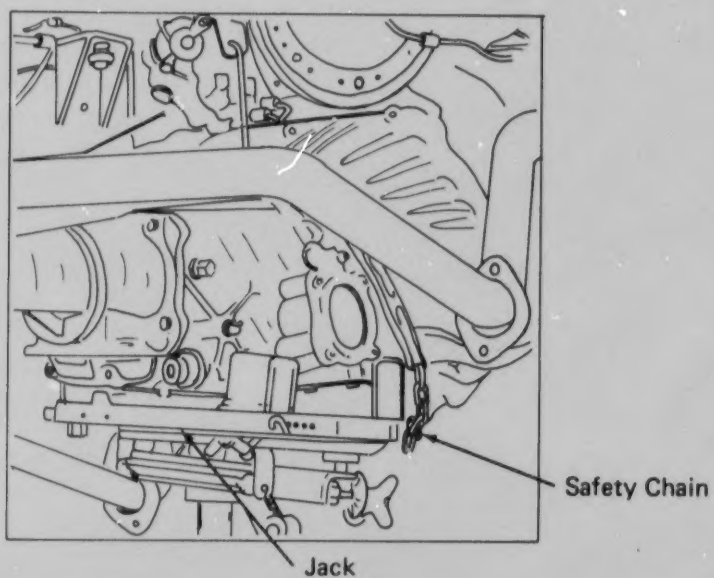
- I. Tools and materials
 - A. Basic hand tools
 - B. Transmission jack
 - C. Hoist
 - D. Floor jack
 - E. Jack stands
 - F. Wooden blocks
 - G. Drop light
 - H. Creeper
 - I. Shop towels
 - J. Safety glasses
 - K. Drain pan (oil and coolant)
- II. Procedure
 - A. Disconnect the battery GROUND cable
 - B. Remove starter (if needed)
 - C. Remove wires, coolant lines, shift rod, vacuum lines (if used), downshift rod, speedometer cable, filler tube
 - D. Mark and remove the propeller shaft
 - E. Mark and remove any PTO propeller or linkages if used
 - F. Drain the converter and transmission of fluid
 - G. Remove the converter to drive plate fasteners
 - H. Mark the drive plate and converter to assure proper reassembly
 - I. Place a jack under the engine if motor mounts are part of the transmission
(CAUTION: Do not damage the pan.)
 - J. Remove the transmission support to crossmember fasteners, if used

JOB SHEET #1

- K. Raise the engine transmission assembly, if necessary
- L. Position a transmission jack under the transmission

(NOTE: Always secure the transmission to the jack with a safety chain.)
(Figure 1)

FIGURE 1

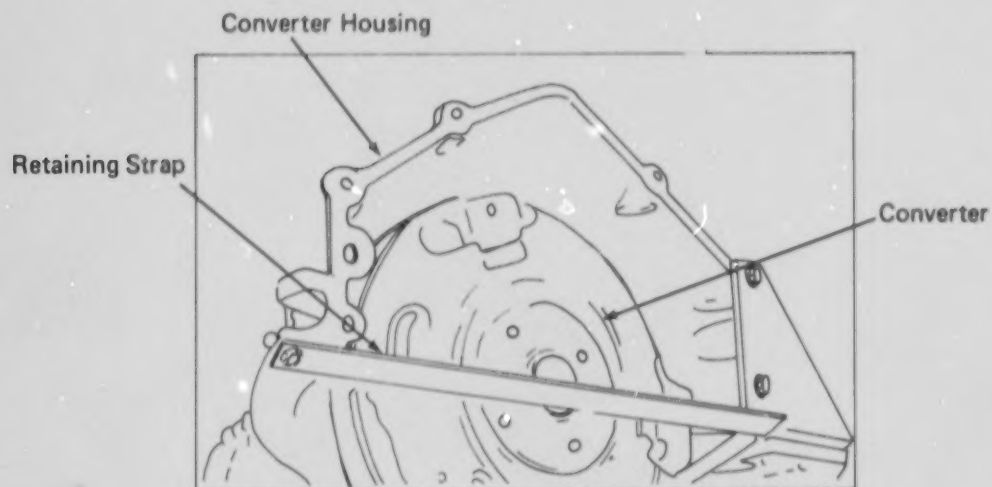


- M. Remove the converter housing to engine fasteners
- (CAUTION: Make sure the engine is supported.)

JOB SHEET #1

- N. Work the transmission and converter back far enough to position a converter retaining strap or bar (Figure 2)

FIGURE 2



- O. Remove the transmission and converter as an assembly
- P. Pull the transmission back until clear of everything and then lower to floor
- (CAUTION: Never let the weight of transmission and converter rest on the drive plate.)

- Q. Stop at this point and have your instructor check and initial your procedure and safe practice

INSTRUCTOR CHECK: Procedure ☐ Safety ☐ Initials ☐

AUTOMATIC TRANSMISSIONS UNIT V

JOB SHEET #2-DISASSEMBLE AN AUTOMATIC TRANSMISSION INTO SUBASSEMBLIES

- I. Tools and materials
 - A. Basic hand tools
 - B. Clean shop towels
 - C. Cleaning solvent in clean container
 - D. Hoist
 - E. Transmission overhaul stand
 - F. Holding plate and holding fixture
 - G. Three-stand lifting sling
 - H. Appropriate service manual
 - I. Special disassembly tools as recommended by manufacturer
 - J. Torque converter retaining strap
 - K. Torque converter lifter
 - L. Front lifter support assembly
 - M. Center support lifter
 - N. Gear unit lifter
 - O. Output shaft lifting tool
 - P. Safety glasses

- II. Procedure

(NOTE: The following procedure and illustrations are adapted from materials published by Detroit Diesel Allison, © General Motors Corporation, and are reprinted with permission; this adaptation does not constitute endorsement by either Detroit Diesel Allison or General Motors Corporation and the procedure may be modified by your instructor to facilitate available equipment.)

- A. Mount the transmission in an overhaul stand with the following procedure:

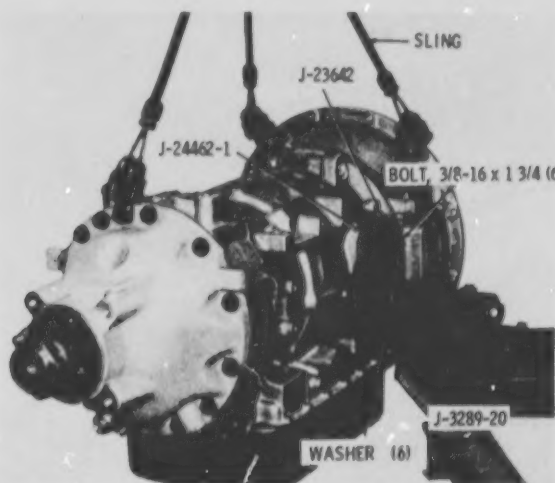
(CAUTION: The torque converter must be held into the transmission by a retaining strap; make sure the strap is in place before lifting the transmission.)

- 1. Remove the six bolts that retain the PTO cover

JOB SHEET #2

2. Remove the cover and gasket
3. Replace the PTO cover with a J-24462-1 holding plate and a J-23642 holding fixture
4. Secure the plate and fixture with six 3/8-16 x 1-3/4-inch bolts (Figure 1)
5. Attach a three-strand lifting sling and hoist the transmission into position for attachment to the J-3289-20 holding fixture base (Figure 1)

FIGURE 1



- B. Check the transmission to be sure the front, rear, and bottom are freely accessible for removal and reinstallation of components

(NOTE: The transmission stand may be mounted in any available turnover stand, but any attachment at the PTO pad should use bolts that will not project into the inside of the housing to obstruct removal and reinstallation of components.)

- C. Check to assure that the stand will permit positioning of the transmission in the following four positions:
1. Horizontal--Top of transmission upward
 2. Horizontal--Bottom of transmission upward
 3. Vertical--Front of transmission upward
 4. Vertical--Rear of transmission upward

JOB SHEET #2

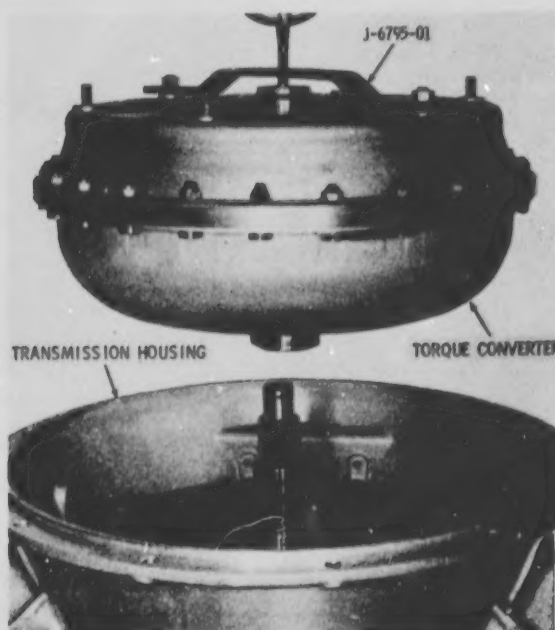
- D. Stop at this point and have your instructor check and initial your procedure and safe practice

INSTRUCTOR CHECK: Procedure ☐ Safety ☐ Initials ☐

- E. Remove torque converter with the following procedure:

1. Position the transmission front upward
2. Check the converter retaining strap to make sure it is firmly secured
3. Attach torque converter lifter J-6795-01
4. Lift complete torque converter from the transmission (Figure 2)

FIGURE 2



5. Set torque converter aside for later disassembly

- F. Stop at this point and have your instructor check and initial your procedure and safe practice

INSTRUCTOR CHECK: Procedure ☐ Safety ☐ Initials ☐

JOB SHEET #2

G. Remove the modulator control and oil pan with the following procedure:

1. Remove the modulator retainer bolt (Figure 3)
2. Remove the modulator control (Figure 3)
3. Remove the 21 washer-head screws that retain the oil pan (Figure 3)
4. Remove the old pan and gasket (Figure 4)

FIGURE 3

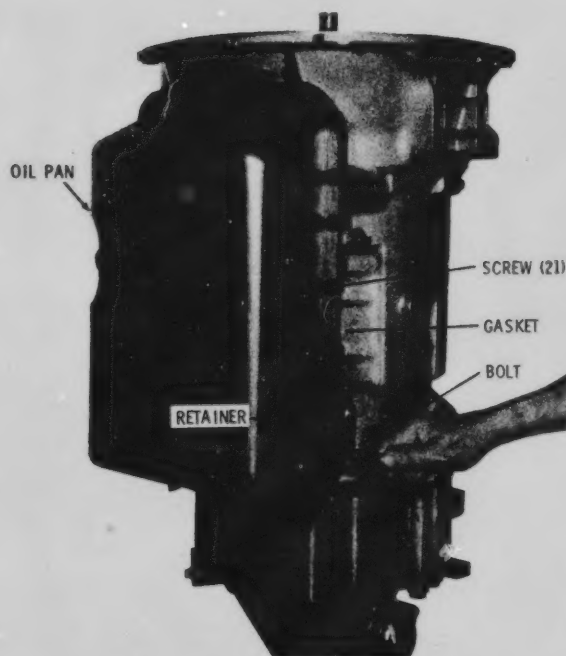
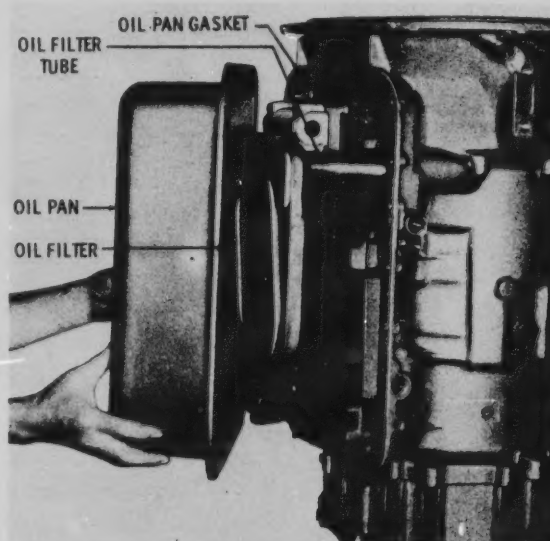


FIGURE 4



H. Stop at this point and have your instructor check and initial your procedure and safe practice

INSTRUCTOR CHECK: Procedure ☐ Safety ☐ Initials ☐

I. Remove oil filter and modulated lockup valve with the following procedure:

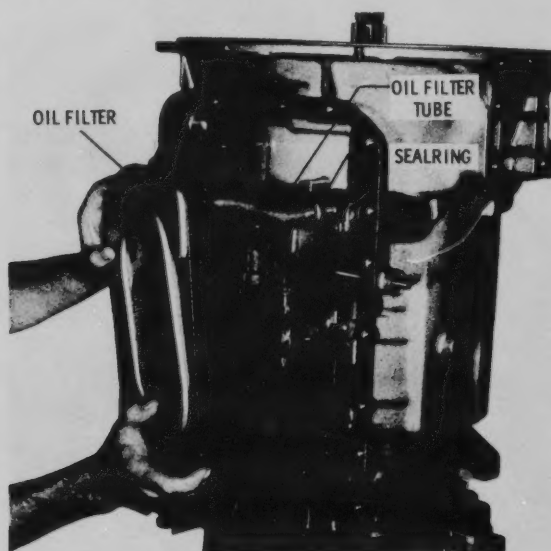
1. Remove the screw that retains the oil filter (Figure 5)
2. Remove and discard the oil filter

JOB SHEET #2

3. Remove the oil filter tube and discard the sealing from the upper end of the tube (Figure 5)

(NOTE: This procedure is for later model oil filters; for earlier model oil filters, the procedure is the same except that the filter and sealing should be discarded after removal.)

FIGURE 5



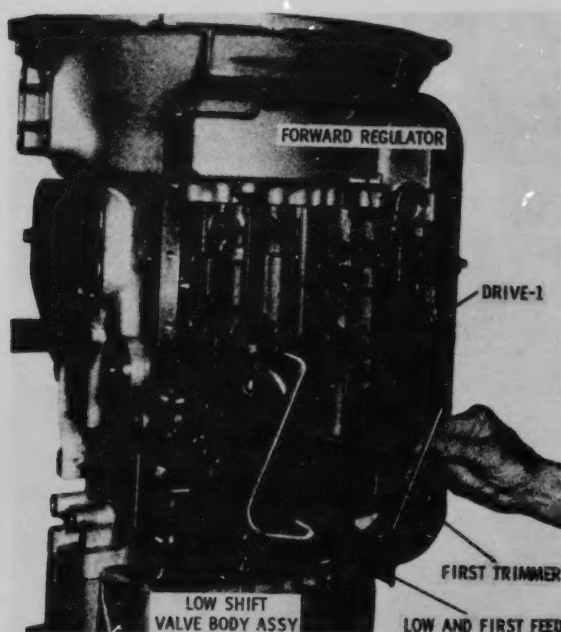
- J. Remove modulated lockup valve body with the following procedure:
 1. Remove the four bolts that retain the valve body (Figure 5)
 2. Remove the valve body assembly and place it in a safe, clean place for inspection
- K. Stop at this point and have your instructor check and initial your procedure and safe practice

INSTRUCTOR CHECK: Procedure ☐ Safety ☐ Initials ☐

JOB SHEET #2

- L. Remove the low shift valve and control valve body assembly with the following procedure:
1. Remove the following tubes: drive-1, forward regulator, low and first feed, the first trimmer (Figure 6)

FIGURE 6

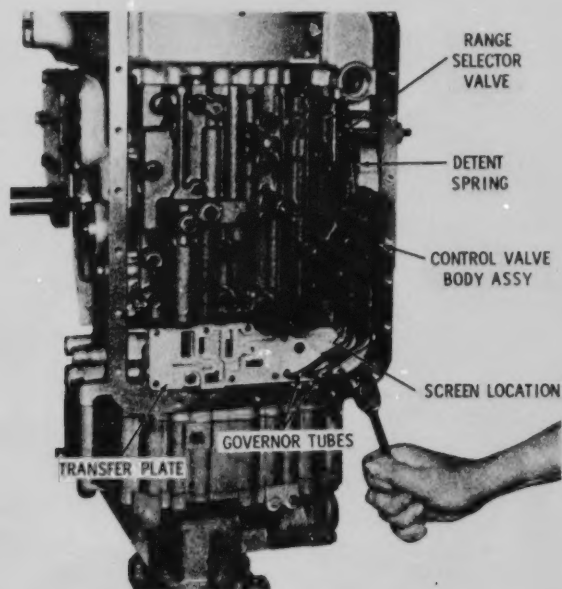


2. If the tubes are fastened to the control valve body with bolts, remove the bolts and tubes
3. Remove the bolts that retain the low shift valve assembly
4. Remove the valve body assembly
5. Remove the separator plate which is directly behind the valve body

JOB SHEET #2

6. Remove the two bolts that attach the low shift oil transfer plate (Figure 7)

FIGURE 7



7. Remove the oil transfer plate and two governor tubes as an assembly
8. Remove and discard the filter screen from a tube bore in the control valve assembly
9. Secure the range selector valve to a pad on the control valve body with a rubber band (Figure 8)
10. Remove the bolt that attaches the detent spring and roller assembly
11. Remove the detent spring and roller assembly (Figure 7)
12. Loosen two bolts at the top of the control valve body to act as support bolts
13. Remove the remaining bolts that attach the control valve body to the transmission housing
14. Hold the control valve body assembly firmly and remove the two remaining bolts (Figure 8)

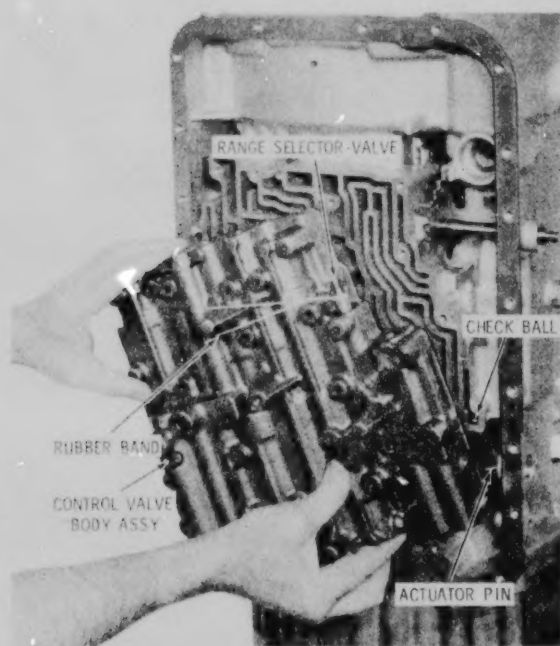
(CAUTION: Perform this part of the procedure with extra care to prevent loss of the governor check ball.)

JOB SHEET #2

15. Remove the control valve in a downward and outward movement to clear the actuator pin from the housing bore (Figure 8)
16. Remove the check ball (Figure 8)
17. Place low shift valve and control valve body assemblies in a safe, clean place for inspection

(NOTE: On Allison models MT 640 and 643, this procedure requires removal of the tube adapter assembly; check with your instructor for special directions.)

FIGURE 8



- M. Stop at this point and have your instructor check and initial your procedure and safe practice

INSTRUCTOR CHECK: Procedure ☐ Safety ☐ Initials ☐

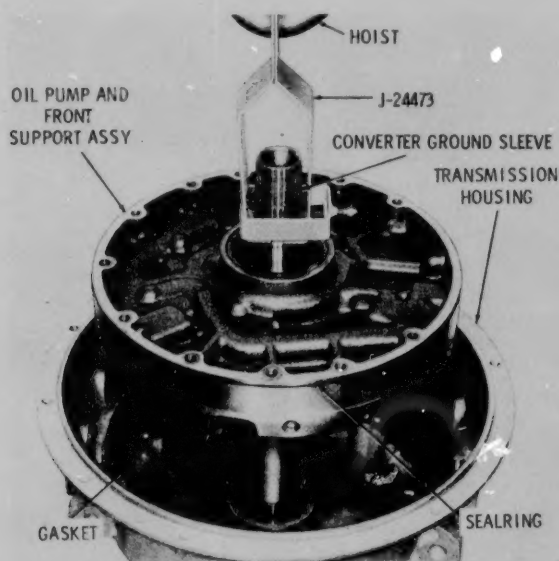
- N. Remove the oil pump and forward clutch with the following procedure:

1. Remove the twelve bolts and twelve rubber-covered washers that retain the oil pump and front support assembly
2. Install front lifter support assembly J-24473 onto the converter ground sleeve (Figure 9)

JOB SHEET #2

3. Check to make sure the lifter assembly is secure before removing the support assembly
4. Attach a hoist to the lifter assembly and carefully remove the oil pump and front support assembly (Figure 9)

FIGURE 9



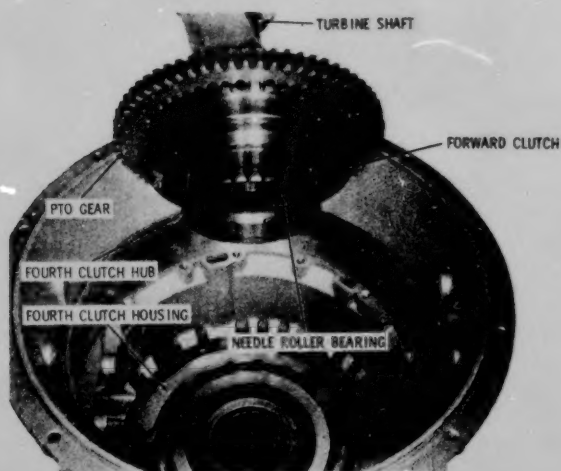
5. Remove the support gasket
6. Remove the bearing and one race at the rear of the support assembly; leave the other race on the support hub

(CAUTION: The pump and front support assembly is fitted to the transmission housing with very little clearance; if the housing is cold, it may bind; if so, heat the housing slightly with a current of warm air or a sun lamp, not a torch, then, if the pump and support assembly starts upwards and binds, tap it downward and lift again.)

JOB SHEET #2

7. Remove the forward clutch by grasping the turbine shaft and lifting the forward clutch and attached PTO gear and fourth clutch hub from the transmission housing (Figure 10)

FIGURE 10



8. Remove the bearing and two races at the rear of the clutch
- O. Stop at this point and have your instructor check and initial your procedure and safe practice

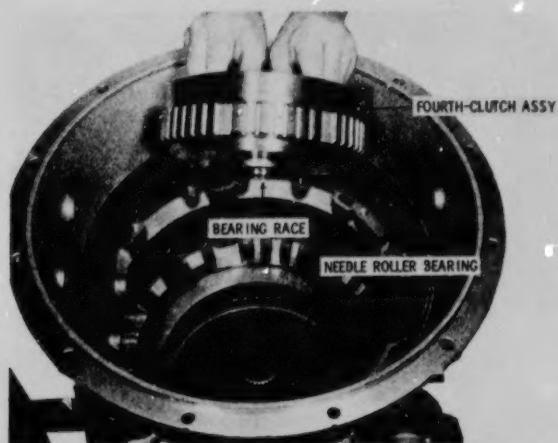
INSTRUCTOR CHECK: Procedure ☐ Safety ☐ Initials ☐

JOB SHEET #2

P. Remove the fourth and third clutches and center support with the following procedure:

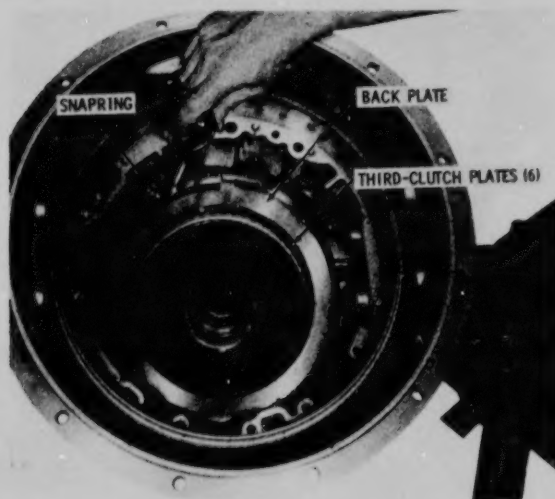
1. Grasp the spring retainer of the fourth clutch, and lift the fourth clutch assembly from the transmission (Figure 11)

FIGURE 11



2. Remove the bearing and race at the rear of the clutch assembly, and leave the other race on the support hub
3. Remove the snapping that retains the third clutch back plate (Figure 12)

FIGURE 12



JOB SHEET #2

4. Remove the back plate
5. Remove the six plates of the third clutch
6. Remove the center support anchor bolt and washer from the bottom of the transmission and discard the bolt (a new bolt will be used for reassembly)
7. Remove the snapping that retains the center support assembly (Figure 13)

FIGURE 13



8. Place center support lifter J-24455 into the recess between the sealrings on the support hub

(CAUTION: The center support is fitted to the transmission case with very little clearance; if the case is cold it may bind; if so, heat the case slightly with a current of warm air or a sun lamp, not a torch, then, if the support assembly starts upwards and binds, tap it downward and lift again.)

JOB SHEET #2

9. Remove the center support assembly from the transmission (Figure 14)

FIGURE 14



- Q. Stop at this point and have your instructor check and initial your procedure and safe practice

INSTRUCTOR CHECK: Procedure ☐ Safety ☐ Initials ☐

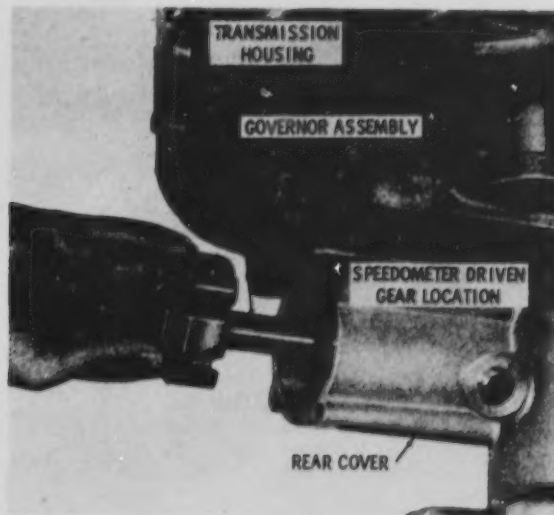
- R. Remove the governor and the gear unit with the following procedure:
1. Remove the four bolts that retain the governor cover
 2. Remove the cover and gasket

JOB SHEET #2

3. Remove the governor assembly carefully (Figure 15)

(NOTE: If the speedometer driven gear has not been previously removed from the transmission rear cover, remove it.)

FIGURE 15



JOB SHEET #2

4. Install gear unit lifter J-24454 behind the splines of the main shaft (Figure 16)

FIGURE 16



5. Attach a hoist to the lifter and remove the gear unit from the transmission housing

(NOTE: Some models may require only removal of the gear unit according to the procedure just outlined, but when a governor must be removed, the governor drive gear, speedometer drive gear, and sleeve spacer may remain on the output shaft or in the transmission housing; check with your instructor for directions.)

- T. Stop at this point and have your instructor check and initial your procedure and safe practice

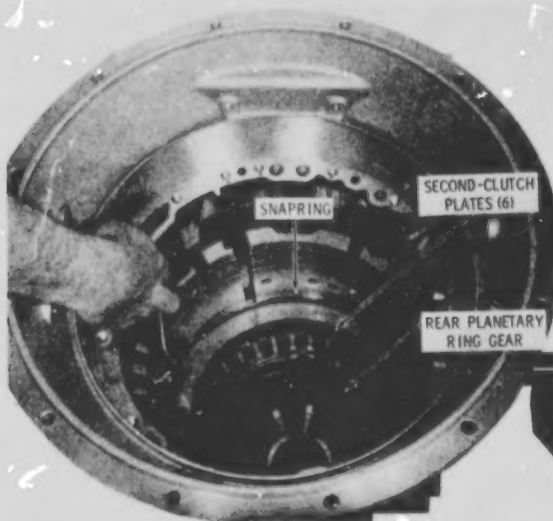
INSTRUCTOR CHECK: Procedure ☐ Safety ☐ Initials ☐

JOB SHEET #2

U. Remove the second and first clutches with the following procedure:

1. Remove the second clutch by removing the snapping that positioned the center support assembly (Figure 17)

FIGURE 17



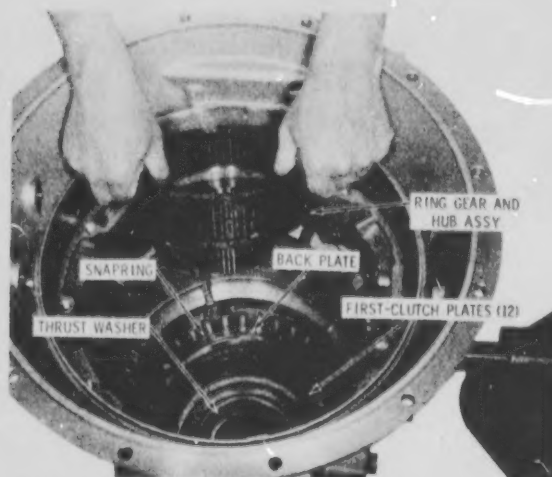
2. Remove the six plates of the second clutch and remove the back plate

JOB SHEET # 2

3. Remove the first clutch by removing the rear planetary ring gear and hub assembly from the transmission (Figure 18)

(NOTE: If replacement parts are required, it may be necessary to remove the snapping and separate ring gear from the ring gear hub; check with your instructor.)

FIGURE 18



4. Remove the snapping that retains the first clutch back plate, and remove the back plate (Figure 18)
5. Remove the 12 plates of the first clutch
6. Remove the thrust washer
7. Stop at this point and have your instructor check and initial your procedure and safe practice

INSTRUCTOR CHECK: Procedure ☐ Safety ☐ Initials ☐

JOB SHEET #2

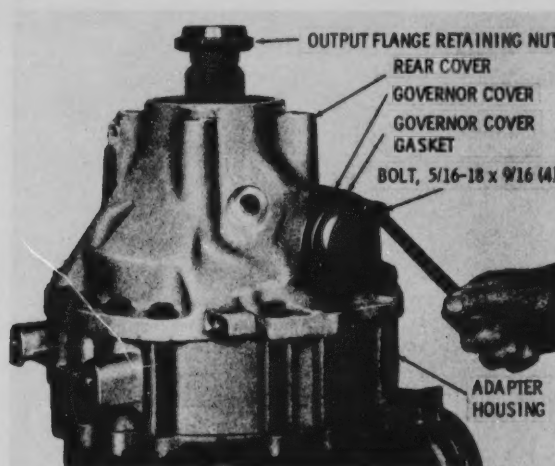
- W. Remove the governor, rear cover, and low clutch components with the following procedure:

(NOTE: Allison MT 650 model transmissions with serial numbers 49996 through 55402 may include a spacer between the output flange and the output shaft rear bearing, and should be installed unless the output shaft is being replaced; check with your instructor for additional directions.)

1. Remove the four bolts that attach the governor cover to the rear cover (Figure 19)

(NOTE: Governor cover and gasket and speedometer drive gear, if not previously removed should be removed according to directions in step R.)

FIGURE 19

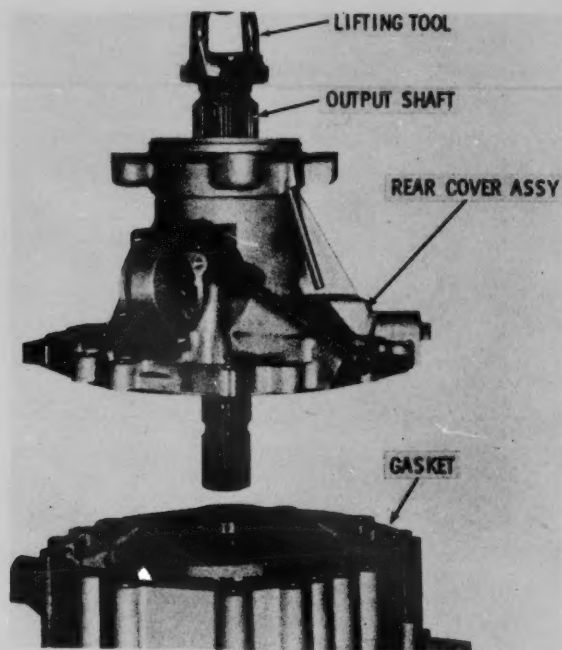


2. Remove the rear cover by attaching a lifting tool to the output shaft (Figure 20)
3. Remove 14 bolts and washers from the rear cover
4. Attach the hoist to the lifting tool
5. Lift carefully and separate the rear cover assembly from the adapter housing (Figure 20)

JOB SHEET #2

6. Remove the rear cover gasket (Figure 20)

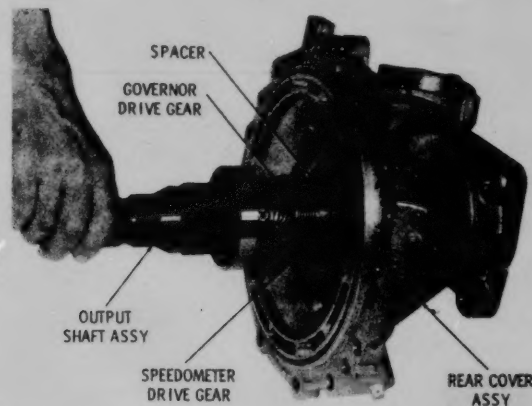
FIGURE 20



JOB SHEET #2

7. Remove the output shaft and attached parts from the rear cover assembly (Figure 21)

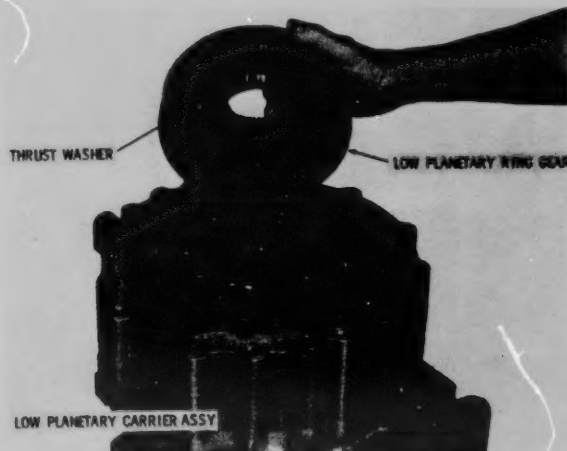
FIGURE 21



(NOTE: On later Allison models which have a roller bearing next to the governor drive gear, the roller bearing outer race will stay in the rear cover; on earlier MT 650 models, remove the spacer, speedometer drive gear, and governor drive gear from the output shaft; on later MT 650 and all MT 653 models, remove only the spacer and speedometer drive gear.)

8. Remove the low clutch by removing the planetary gear ring (Figure 22)

FIGURE 22

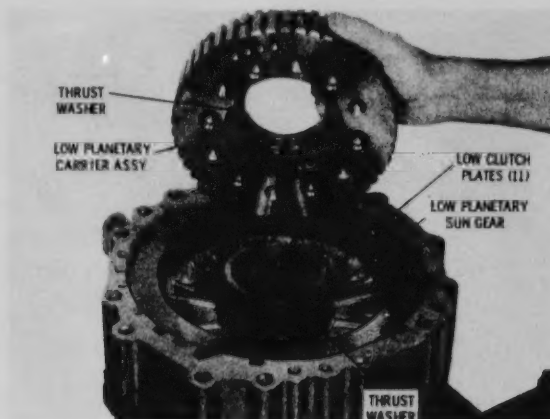


9. Remove the thrust washer from the ring gear hub

JOB SHEET #2

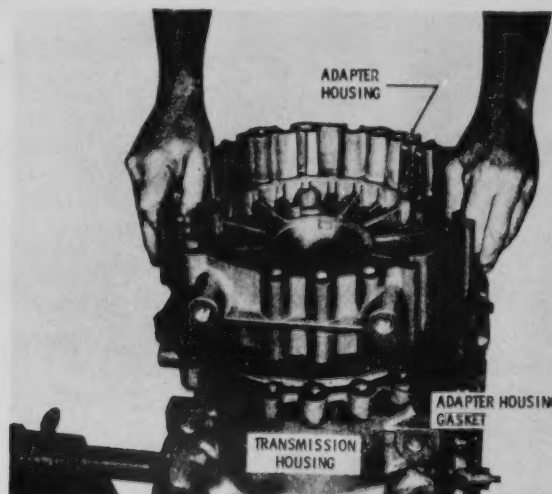
10. Remove the low planetary carrier assembly (Figure 23)
11. Remove the thrust washer from the carrier (Figure 23)
12. Remove the sun gear, thrust washer, and the eleven low clutch plates (Figure 23)

FIGURE 23



13. Remove the adapter housing and attached first clutch piston components (Figure 24)

FIGURE 24



14. Remove the gasket (Figure 24)

JOB SHEET #2

- X. Stop at this point and have your instructor check and initial your procedure and safe practice

INSTRUCTOR CHECK Procedure ☐ Safety ☐ Initials ☐

- Y. Remove second and first clutches and rear cover with the following procedure on models 640 and 643:

1. To remove the second clutch, remove the snapping that positions the center support assembly
2. Remove six clutch plates and the clutch back plate

(NOTE: This procedure should have been accomplished in step U, but is repeated to emphasize its relationship to this part of the procedure.)

3. To remove the first clutch, remove the snapping that retains the first clutch back plate
4. Remove ten clutch plates, ring gear, and back plate as an assembly (Figure 25)

FIGURE 25

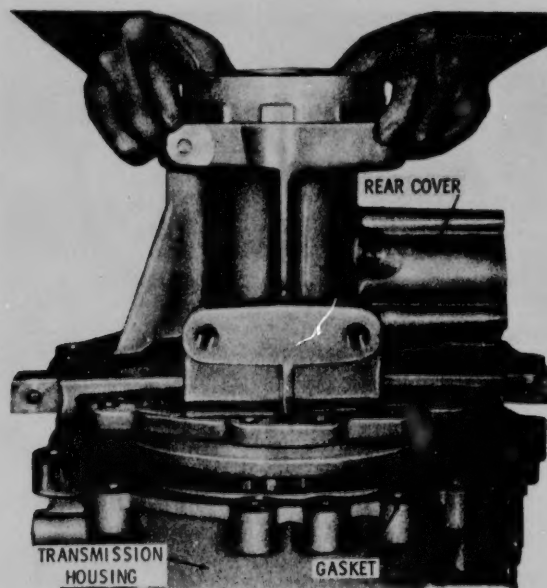


5. To remove the rear cover, invert the transmission
6. Remove the speedometer driven gear if it has not already been removed

JOB SHEET #2

7. Remove the fourteen bolts and washers that retain the rear cover to the transmission housing
8. Carefully remove the rear cover assembly and attached parts (Figure 26)
9. Remove the rear cover gasket (Figure 26)

FIGURE 26



- Z. Stop at this point and have your instructor check and initial your procedure and safe practice

INSTRUCTOR CHECK: Procedure ☐ Safety ☐ Initials ☐

AUTOMATIC TRANSMISSIONS
UNIT V

JOB SHEET #3-CHECK END PLAY ON A TORQUE CONVERTER ASSEMBLY

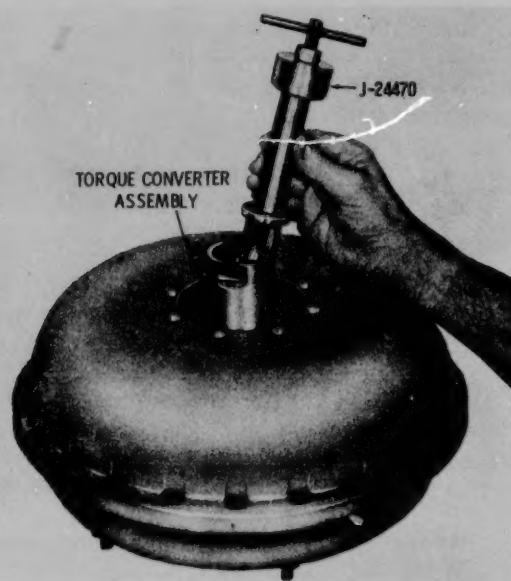
- I. Tools and materials
 - A. Basic shop tools
 - B. Clean shop towels
 - C. Cleaning solvent in a clean container
 - D. Converter end play gauge
 - E. Dial indicator
 - F. Appropriate service manual

II. Procedure

(NOTE: The following procedure and illustrations are adapted from materials published by Detroit Diesel Allison, © General Motors Corporation, and are reprinted with permission; this procedure may be modified by your instructor to facilitate available equipment.)

- A. Support the converter assembly on the converter cover with pump hub upward
- B. Place converter end play gauge J-24470 into the converter pump hub (Figure 1)

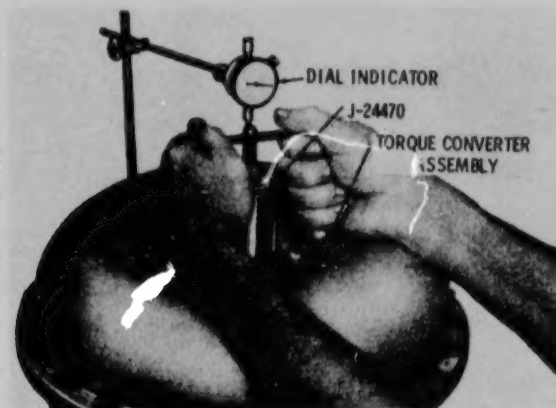
FIGURE 1



JO3 SHEET #3

- C. Hold the center screw of the gauge and tighten the nut until the gauge is securely retained, but do not overtighten
- D. Install the dial indicator as shown in Figure 2

FIGURE 2



- E. Adjust the indicator bracket so the stem of the indicator is in firm contact with the top of the center screw
- F. Set the dial to read zero
- G. Use both hands as shown in Figure 2 to lift the center screw as far as possible
- H. Record dial indicator reading and determine results according to the following general rules:
 1. End play exceeding 0.025 inch indicates wear of converter components, and requires replacement of worn components and the selection of a new spacer
 2. If end play does not exceed 0.025 inch, the converter may be disassembled for inspection and cleaning, and reassembled with the same spacer except when major parts must be replaced

(NOTE: After disassembly of the torque converter assembly, end play should be checked again at the time of reassembly; the procedure is the same as outlined above, but slightly different rules apply, and they are explained in the following steps.)
- I. Record dial indicator reading and compare it with Dimension B in the SPACER CHART that follows

JOB SHEET #3

J. Select the proper size spacer from the chart (Figure 3)

FIGURE 3

Dimension B	SPACER CHART	
	Use Part No.	Color
Less than 0.0177	Use no spacer	
0.0177-0.034	6837429	Gold
0.034-0.049	6837430	Silver
0.049-0.062	6837431	Plain
0.062-0.079	6837432	Black
0.079-0.093	6837433	Copper

(NOTE: The part numbers and color codes listed above are from Detroit Diesel Allison specifications; spacer part numbers and color codes will obviously vary with the manufacturer; checking end play first and correcting problems will save time at later stages in the reassembly of automatic transmission components.)

K. Stop at this point and have your instructor check and initial your procedure and safe practice

INSTRUCTOR CHECK: Procedure ☐ Safety ☐ Initials ☐

**AUTOMATIC TRANSMISSIONS
UNIT V**

**JOB SHEET #4-DISASSEMBLE, CLEAN, AND INSPECT
A TORQUE CONVERTER ASSEMBLY**

I. Tools and materials

- A. Basic hand tools
- B. Clean shop towels
- C. Cleaning solvent in a clean container
- D. Compressed air supply for drying parts
- E. Wood surface work area
- F. Oil can and lubricating oil
- G. Bearing installer
- H. Appropriate service manual
- I. Safety glasses

II. Procedure:

(NOTE: The following procedure and illustrations are adapted from materials published by Detroit Diesel Allison, © General Motors Corporation, and are reprinted with permission; your instructor may modify the procedure to facilitate available equipment.)

- A. Remove six retainers 3 and six spacers 4 from the converter assembly cover 6
- B. Remove twenty-four nuts 5 from cover 6

(NOTE: Refer to the parts list and exploded view that accompany this job sheet for parts identification, and retain the parts list and exploded view for use with Job Sheet #6.)

JOB SHEET #4

- C. Remove, as a unit, the converter cover, lockup clutch piston, and related parts (Figure 1)

FIGURE 1



- D. Place cover assembly on the work table with the lockup clutch piston up
- E. Remove bearing race 16
- F. Compress the center of piston 10 and remove snapring 15
- G. Turn cover assembly over, piston down, and bump the cover sharply on a wood surface to remove the piston
- H. Remove sealring retainer 8 and sealring 9 from cover
- I. Remove sealring 11 from piston 10
- J. Inspect bushing 7 for scores, burrs, roundness, sharp edges, and evidence of overheating
- K. Remove bushing scores with crocus cloth
- L. Remove burrs or sharp edges on bushing with a scraper or knife blade
- M. Inspect bushing 7 for being out-of-round, deeply scored, or excessively worn; if any of these conditions exist, replace it with a proper size replacement

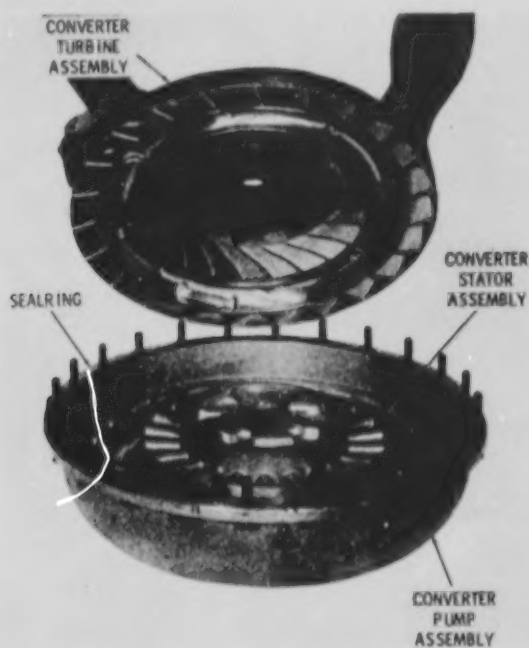
(CAUTION: Whenever it is necessary to cut out a defective bushing, use care not to damage the bore into which the bushing fits.)

- N. Remove lockup clutch plate 12

JOB SHEET #4

- C. Remove lockup clutch back plate 14 from torque converter pump 33
- P. Remove sealring 13 from plate 14
- Q. Remove roller bearing assembly 17, bearing race 18, and spacer 19 from the hub of turbine
- R. Remove the converter turbine assembly (Figure 2)

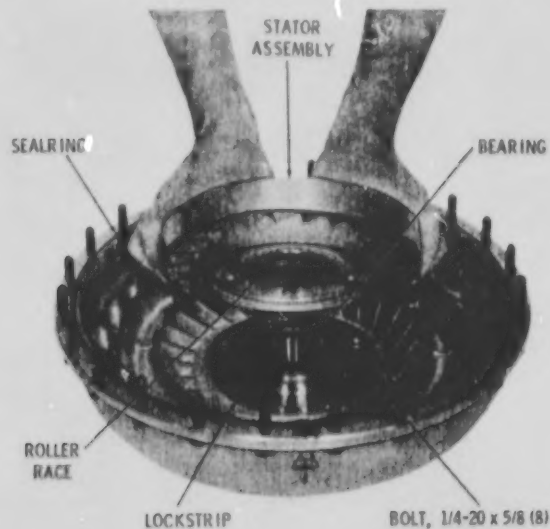
FIGURE 2



JOB SHEET #4

- S. Grasp the stator and the roller race as shown in Figure 3 and remove as a unit

FIGURE 3



- T. Position stator assembly 21 on the work table so that the freewheel roller race 23 is upward
- U. Remove the roller race by rotating it clockwise while lifting it out of the converter stator
- V. Remove the ten rollers 25 and ten springs 24 from stator 21
- W. Check needle bearing assembly 22
- X. Wash and flush the needle bearing assembly thoroughly with dry cleaning solvent or mineral spirits
- Y. Dry the needle bearing and lubricate with transmission oil
- Z. Replace the freewheel race only and rotate the bearing while pressing upon the freewheel race; if there is no roughness or binding, the needle bearing assembly may be left in the stator and cam assembly and reused
- (NOTE: Do not mistake dirt or grit for a damaged needle bearing.)
- AA. Reclean and re-oil the needle bearing if dirt is suspected
- BB. Check the needle bearing end of freewheel race for smooth finish
- CC. Replace the freewheel race if the bearing end is scratched or contains chatter marks

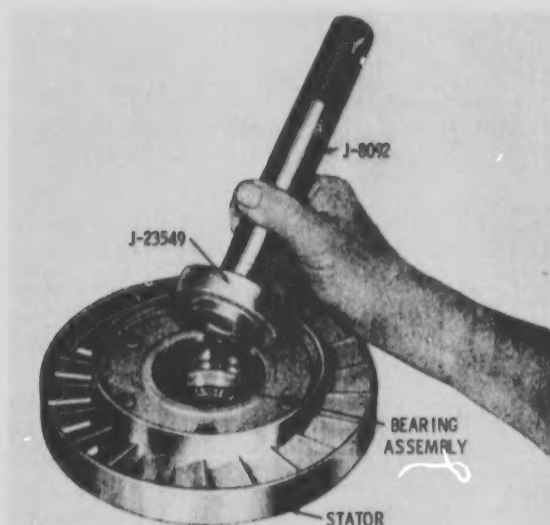
JOB SHEET #4

D. Replace needle bearing assembly 22, if required, with the following procedure:

(CAUTION: Do not scratch or nick any stator bores; do not attempt to disassemble the stator and cam assembly.)

1. Remove needle bearing carefully to avoid nicking the aluminum bore in which it is held
2. Place a new bearing assembly, thrust race first, into the aluminum bore of the stator
3. Install the thrust bearing by using bearing installer J-23549 (Figure 4)

FIGURE 4



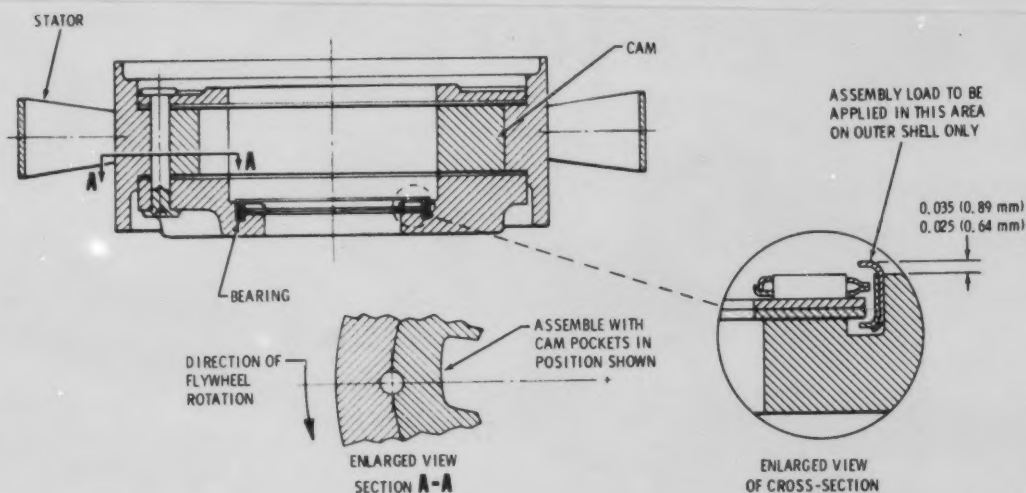
JOB SHEET #4

4. Drive the bearing assembly into the stator until the top of the outer shell is 0.025 to 0.035 inch above the shoulder in the side plate (Figure 5)

(NOTE: The installing tool will seat on the stator area surrounding the bearing when the bearing is properly installed.)

(CAUTION: Apply the load only to the outer shell of the bearing during installation.)

FIGURE 5



5. Remove bearing 26 and bearing race 27 from converter pump hub 30

(NOTE: This step applies to Allison models with serial numbers prior to 49489; models with later serial numbers require removal of the needle bearing, bearing race, and roller bearing from the converter pump hub, and then removal of a sealring.)

6. Flatten the corners of lockstrips 29 or 39 and remove eight bolts 28 or 40 and four lockstrips from converter pump hub 30 or 36
7. Remove hub 30 or 36 and gasket 31 from pump 33
8. Remove sealring 35 from hub 36
9. Clean and dry parts for inspection and reassembly
10. Inspect all parts for damage or excessive wear

JOB SHEET #4

EE. Stop at this point and have your instructor check and initial your procedure and safe practice

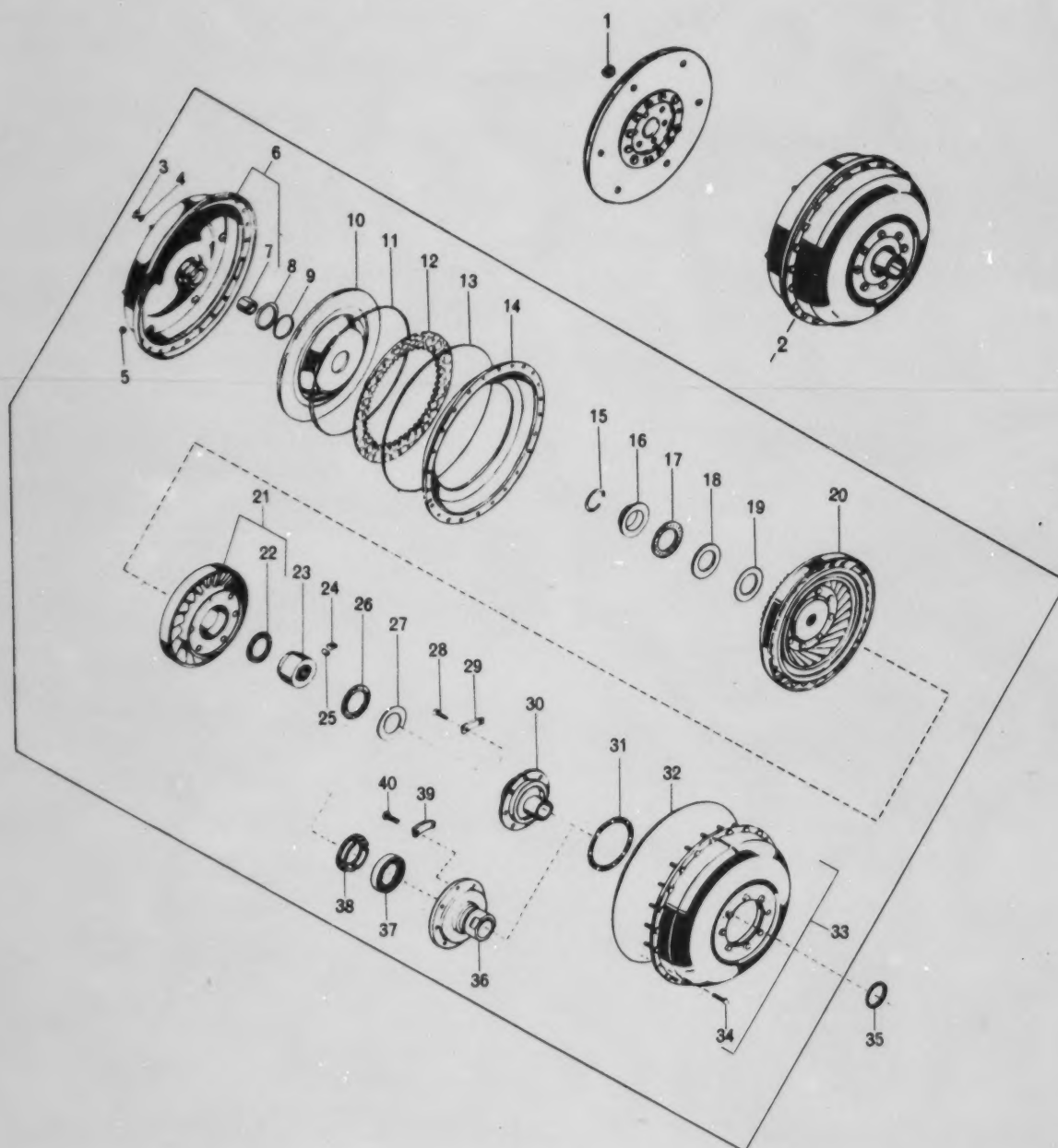
INSTRUCTOR CHECK: Procedure ☐ Safety ☐ Initials ☐

JOB SHEET #4--PARTS LIST FOR TORQUE CONVERTER
AND LOCKUP CLUTCH

- | | |
|------------------------------------|--|
| 1 - Flexible disk nut, 3/8-24 (6) | 20 - Converter turbine |
| 2 - Torque converter assembly | 21 - Converter stator assembly |
| 3 - Spacer retainer (6) | 22 - Needle bearing assembly |
| 4 - Spacer (6) | 23 - Freewheel roller race |
| 5 - Self-locking nut, 5/16-24 (24) | 24 - Freewheel roller spring (10) |
| 6 - Converter cover assembly | 25 - Freewheel roller (10) |
| 7 - Bushing | 26 - Needle bearing assembly |
| 8 - Sealring retainer | 27 - Bearing race (before S/N 49490) |
| 9 - Piston inner sealring | 28 - Bolt, 1/4-20 x 5/8 (8) |
| 10 - Lockup clutch piston | 29 - Lock strip (4) |
| 11 - Piston outer seal | 30 - Converter pump hub (before S/N 49490) |
| 12 - Lockup clutch plate | 31 - Gasket |
| 13 - Sealring | 32 - Sealring |
| 14 - Lockup clutch back plate | 33 - Converter pump assembly |
| 15 - Snapring | 34 - Bolt, 5/16-24 x 1.3 (24) |
| 16 - Bearing race | 35 - Sealring (after S/N 49489) |
| 17 - Thrust bearing assembly | 36 - Converter pump hub (after S/N 49489) |
| 18 - Bearing race | 37 - Roller Bearing (after S/N 49489) |
| 19 - Thrust bearing spacer (ar): | 38 - Bearing race (after S/N 49489) |
| .0177-.034 (gold) | 39 - Lock strip (4) |
| .034-.049 (Silver) | 40 - Bolt, 1/4-20 x 5/8 (8) |
| .049-.062 (Plain) | |
| .062-.079 (Black) | |
| .079-.0933 (Copper) | |

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JOB SHEET #4--EXPLODED VIEW FOR TORQUE CONVERTER
AND LOCKUP CLUTCH



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AUTOMATIC TRANSMISSIONS
UNIT V

JOB SHEET #5-REBUILD A STATOR ASSEMBLY

- I. Tools and materials
 - A. Basic hand tools
 - B. Clean shop towels
 - C. Cleaning solvent in a clean container
 - D. Compressed air for drying parts
 - E. Hydraulic press (minimum 5-ton capacity)
 - F. Adjustable table
 - G. Pressure gauge to determine rivet staking loads
 - H. 3/8-inch drill
 - I. Fixture stand
 - J. Rivet remover pin
 - K. 100 foot-pound torque wrench
 - L. Base plate and top plate
 - M. Rubber mallet
 - N. Stake tool
 - O. 5/8-11 x 3.25 inch retaining bolt
 - P. Appropriate service manual
 - Q. Safety glasses

II. Procedure

(NOTE: The following procedure and illustrations are adapted from materials published by Detroit Diesel Allison, © General Motors Corporation, and are reprinted with permission; your instructor may modify the procedure to facilitate available equipment.)

- A. Inspect the stator assembly to make certain that it needs rebuilding, and rebuild or replace according to the following:
 - 1. If stator thrust washer 28, rivets 22, or washer 23, require replacement, rebuild the assembly

(NOTE: Refer to the parts list and exploded view that accompany this job sheet for parts identification.)

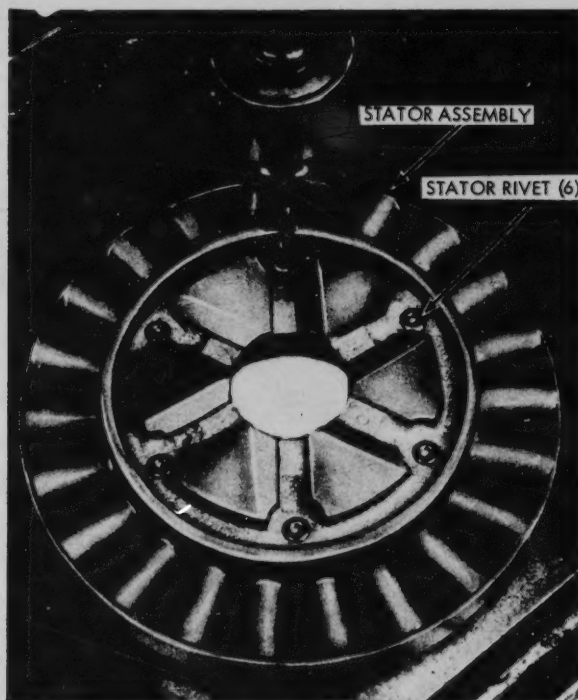
JOB SHEET #5

2. If stator 26 or cam 25 is cracked or damaged, replace the complete stator assembly

B. Rebuild the stator assembly with the following procedure:

1. Place the stator assembly in a drill press, formed rivet side up (Figure 1)

FIGURE 1

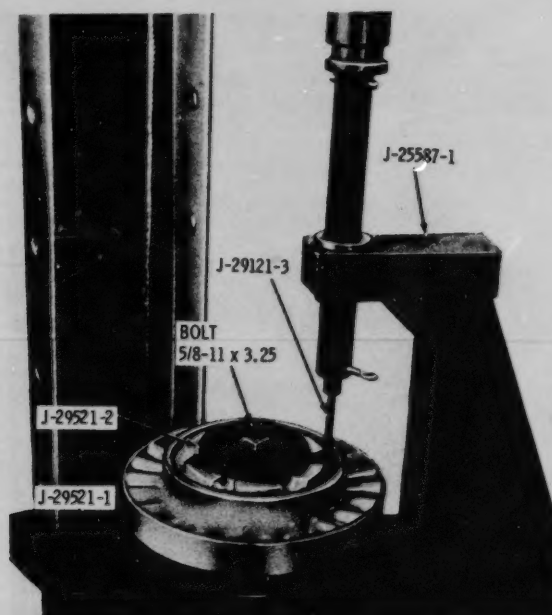


2. Using a 3/8-inch drill, align and drill the rivet, removing the formed head
3. Place base plate J-29521-1 under the stator assembly, making sure the holes in the baseplate are under the rivet heads (Figure 2)

JOB SHEET #5

4. Place top plate J-29521-2 on top of the stator assembly (Figure 2)

FIGURE 2



5. Install the 5/8-11 x 3.25-inch bolt to hold the two plates together
6. Tighten the bolt to 60 lb ft torque
7. Place fixture stand J-25587-1 on a hydraulic press (Figure 2)
8. Install rivet remover pin J-29121-3 into fixture J-25587-1 head
9. Tighten the tool retainer thumb screw
10. Place the stator assembly, with base and top plates, onto the fixture stand, drilled rivet side up
11. Align the rivet remover pin with the drilled rivet and press the rivet from the stator assembly
12. Repeat the above process for each rivet
13. Remove the retaining bolt and top plate (Figure 1)
14. Separate thrust washer 28, side plate washer 23, two cam washers 24, and cam 25 from stator 26

JOB SHEET #5

15. Inspect the stator and cam for cracks, and rivet holes for burrs or swelling

16. Remove burrs with crocus cloth or soft honing stone

(CAUTION: If cam or stator is cracked or distorted, replace the complete stator assembly.)

17. Clean stator assembly components

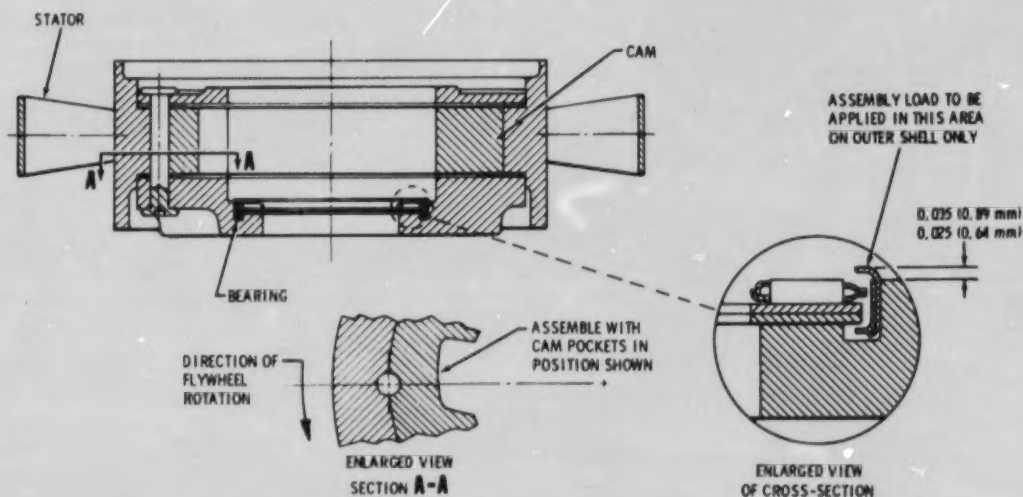
C. Stop at this point and have your instructor check and initial your procedure and safe practice

INSTRUCTOR CHECK: Procedure ☐ Safety ☐ Initials ☐

D. Reassemble the stator assembly with the following procedure:

1. Assemble cam 25 and stator 26 with the roller pocket positioned as shown in Figure 3
2. Install cam washer 24, one on each side of the stator
3. Install freewheel washer 18 and thrust washer 13

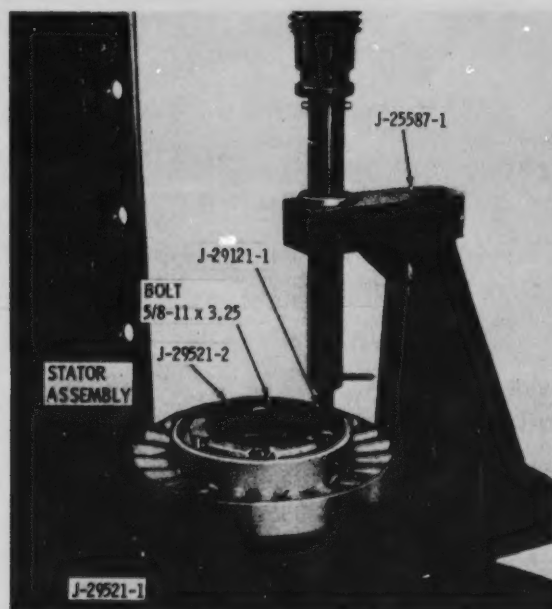
FIGURE 3



JOB SHEET #5

4. Align the six rivet holes and insert six new 1/4 x 1.94-inch rivets into the stator assembly from the rear to front of the stator (Figure 4)

FIGURE 4



5. Place the stator assembly on base plate J-29521-1 (Figure 4), and be sure the rivet heads rest on the base plate, between clearance holes
6. Install top plate J-29521-2 and the 5/8-11 x 3/25-inch retaining bolt
7. Strike the top plate with a rubber mallet to seat components
8. Tighten retainer bolt to 60 lb ft torque
9. Place the stator assembly on fixture J-25587-1
10. Install stake tool J-29121-1 into fixture head of J-25587-1
11. Tighten the thumb screw finger tight
12. Apply approximately 8000 pound load to swage each rivet head

(NOTE: The amount of force to apply will vary depending on the condition of the swaging tool and the press equipment being used.)

JOB SHEET #5

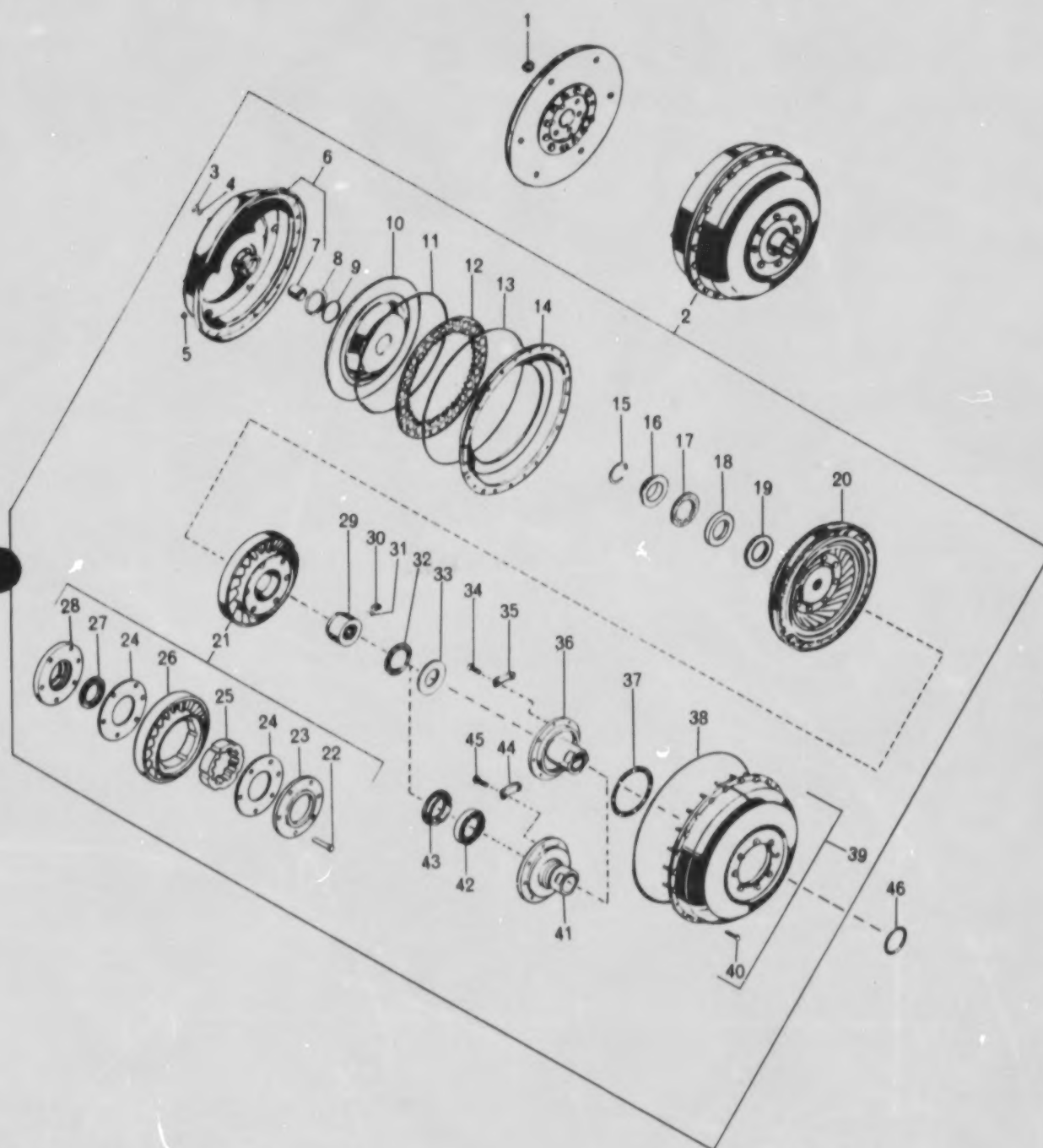
13. Swage the second rivet 180 degrees (3.15 rad) from the first
 14. Locate the third rivet, 60 degrees (1.05 rad) from the second, and swage it
 15. Locate the fourth rivet 180 degrees (3.15 rad) from the third, etc., until all rivets are swaged
 16. Remove the top and bottom plate retaining bolt from stator assembly 21
 17. Remove the two plates
 18. Install new needle bearing, if required, according to procedure previously outlined
 19. Inspect stator assembly to make sure it is ready for replacement into torque converter assembly
- E. Stop at this point and have your instructor check and initial your procedure and safe practice

INSTRUCTOR CHECK: Procedure ☐ Safety ☐ Initials ☐

JOB SHEET #5--PARTS LIST FOR STATOR ASSEMBLY

- | | | | |
|--|---------------------------------|-------|-------|
| 1 - Flexible disk nut, 3/8-24 (6) Ⓐ | 44 - Lock strip (4) | | |
| 2 - Torque converter assembly | 45 - Bolt, 1/4-20 x 5/8 (8) Ⓒ | | |
| 3 - Spacer retainer (6) | 46 - Sealring (after S/N 49489) | | |
| 4 - Spacer (6) | | | |
| 5 - Self-locking nut, 5/16-24 (24) Ⓑ | Torque | lb-ft | N-m |
| 6 - Converter cover assembly | | | |
| 7 - Bushing | Ⓐ 33-40 | | 45-54 |
| 8 - Sealring retainer | Ⓑ 19-23 | | 26-31 |
| 9 - Piston inner sealring | Ⓒ 9-11 | | 12-15 |
| 10 - Lockup clutch piston | | | |
| 11 - Piston outer seal | | | |
| 12 - Lockup clutch plate | | | |
| 13 - Sealring | | | |
| 14 - Lockup clutch back plate | | | |
| 15 - Snapring | | | |
| 16 - Bearing race | | | |
| 17 - Thrust bearing assembly | | | |
| 18 - Bearing race | | | |
| 19 - Thrust bearing spacer (ar): | | | |
| 0.014-0.016 inch (0.36-0.41 mm) (Gold) | | | |
| 0.029-0.031 inch (0.74-0.79 mm) (Silver) | | | |
| 0.041-0.043 inch (1.04-1.09 mm) (Plain) | | | |
| 0.059-0.061 inch (1.50-1.55 mm) (Black) | | | |
| 0.074-0.076 inch (1.88-1.93 mm) (Copper) | | | |
| 20 - Converter turbine | | | |
| 21 - Converter stator assembly | | | |
| 22 - Rivet (6) | | | |
| 23 - Side plate washer | | | |
| 24 - Cam washer (2) | | | |
| 25 - Cam | | | |
| 26 - Stator | | | |
| 27 - Needle bearing assembly | | | |
| 28 - Thrust washer | | | |
| 29 - Freewheel roller race | | | |
| 30 - Freewheel roller spring (10) | | | |
| 31 - Freewheel roller (10) | | | |
| 32 - Needle bearing assembly | | | |
| 33 - Bearing race (before S/N 49490) | | | |
| 34 - Bolt, 1/4-20 x 5/8 (8) Ⓒ | | | |
| 35 - Lock strip (4) | | | |
| 36 - Converter pump hub (before S/N 49490) | | | |
| 37 - Gasket | | | |
| 38 - Sealring | | | |
| 39 - Converter pump assembly | | | |
| 40 - Bolt, 5/16-24 x 1.3 (24) | | | |
| 41 - Converter pump hub (after S/N 49489) | | | |
| 42 - Roller bearing (after S/N 49489) | | | |
| 43 - Bearing race (after S/N 49489) | | | |

JOB SHEET #5-EXPLODED VIEW OF STATOR ASSEMBLY



AUTOMATIC TRANSMISSIONS UNIT V

JOB SHEET #6--REASSEMBLE A TORQUE CONVERTER ASSEMBLY

I. Tools and materials

- A. Basic hand tools
- B. Clean shop towels
- C. Cleaning solvent in a clean container
- D. Compressed air for drying parts
- E. New converter pump gasket
- F. Four new lockstrips
- G. New converter pump flange bolts as required
- H. Stator roller retainer
- I. Bushing installer
- J. 100 foot-pound torque wrench
- K. Appropriate service manual
- L. Safety glasses

II. Procedure

(NOTE: The following procedure and illustrations are adapted from materials published by Detroit Diesel Allison, © General Motors Corporation, and are reprinted with permission; your instructor may modify the procedure to facilitate available equipment.)

- A. Install a new, dry gasket 31 onto converter pump 33

(NOTE: Refer to Job Sheet #4 for Parts List and Exploded View.)

- B. Install hub 30 or 36 into pump 33, aligning the holes in the hub and gasket with the holes in the pump
- C. Install four new lockstrips 29 or 39 and eight 1/4-20 x 5/8 bolts 28 or 40 through hub 30 or 36 in pump 33
- D. Tighten the bolts to 9-11 lb ft torque
- E. Bend the corners of the lockstrips against the bolt heads
- F. Replace any converter pump flange bolts necessary and make sure any weights are in their original positions if pump bolts have been removed

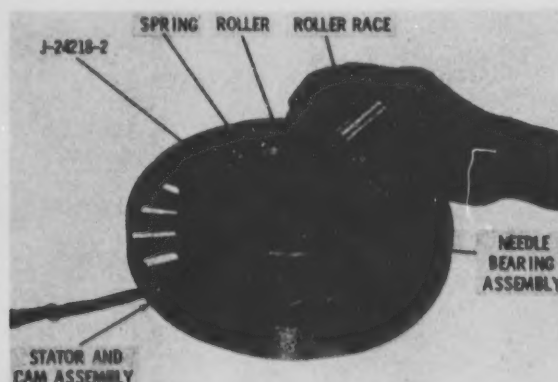
JOB SHEET #6

- G. Install sealring 32 into the groove in the outer circumference of converter pump 33

(NOTE: On Allison models prior to serial number 49489, install bearing race 27 and needle bearing 26 into converter pump hub 30; after serial number 49489, install roller bearing 37, bearing race 38, lugged side first, and needle bearing 26 into converter pump hub 36, and install sealring 35 into the groove of hub 36.)

- H. Place the stator and cam assembly on the work table, bearing side down (Figure 1)

FIGURE 1

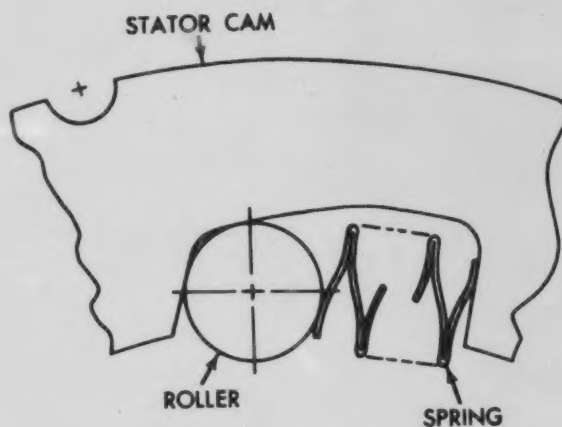


- I. Cover the bottoms of the stator cam pockets with oil-soluble grease
- J. Install stator roller retainer J-24218-1 as shown in Figure 1 so the cord can later be used to remove the retainer
- K. Install ten freewheel rollers and ten springs in the shallow ends of the cam pockets

JOB SHEET #6

- L. Check to make sure the open end of the spring touching the roller is toward the center of the stator cam assembly (Figure 2)

FIGURE 2



- M. Install the freewheel roller race, shoulder-side first (Figure 1), until the race engages the rollers
- N. Rotate the race in a clockwise direction while pressing downward until the race touches the collapsible retainer
- O. Lift up on the stator assembly and pull on the cord to remove the retainer
- P. Continue rotating the race while pressing downward, and when the race is fully seated, rotate it firmly in the opposite direction to lock the stator and cam assembly

JOB SHEET #6

- Q. Grasp the stator and cam assembly, hold the roller race firmly to hold it in position, and install the stator assembly (refer to Job Sheet #4)
- R. Install the converter turbine assembly (refer to Job Sheet #4)
- S. Install the same spacer 19 that was removed at the time of disassembly, only if the end play reading taken before disassembly was satisfactory, and if no parts affecting end play are being replaced
- T. Install the spacer into the hub of converter turbine 20 prior to the following step
- U. Install bearing race 18, outer lip upward, into hub of turbine 20
- V. Grease and install bearing 17 onto the bearing race
- W. Install sealing 13 onto lockup clutch back plate 14
- X. Install the back plate onto the torque converter pump and align the balance mark on the back plate with the balance mark on the converter pump
- Y. Install lockup clutch plate 12 onto plate 14

(NOTE: If the converter cover bushing in the converter hub was removed, use installer J-24648 to install a new bushing as shown in Figure 3; after installation, the bushing inside diameter should be 0.990 to 1.0010 inch.)

FIGURE 3

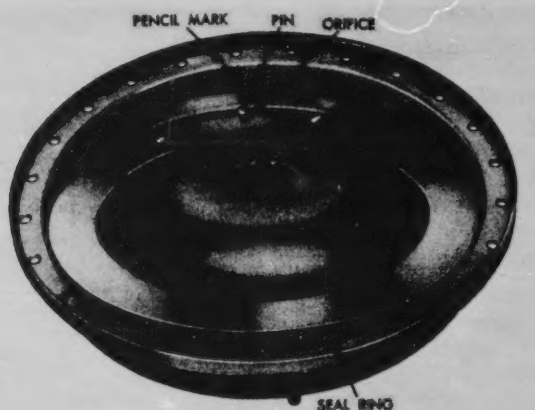


JOB SHEET #6

- Z. Install sealring 8, smaller end first, onto converter hub 6
- AA. Install sealring 9 into retainer
- BB. Install sealring 11 onto piston 10
- CC. Install the lockup clutch piston into the converter cover with the balance marks aligned so that the piston guide pins will enter the nearest holes in the piston (Figure 4)

(CAUTION: The lockup clutch will not release if the piston is not engaged with the pins.)

FIGURE 4



(NOTE: To make installation of the lockup piston easier, place a pencil mark in line with the pin nearest the orifice in the piston, when the balance marks are aligned as shown in Figure 4; then, when the piston is installed, use the pencil mark as a guide for the location of the pin beneath the orifice; one recessed hole is concentric with the orifice; rotate the piston slightly, if necessary, during installation to ensure that the piston engages the pins; to verify that the piston is seated, measure the distance from the pump cover mounting surface to the piston; the distance should be approximately 1 1/2 inches.)

- DD. Using hand pressure on the center of piston 10, install snapping 15
- EE. Install bearing race 16, inner lip first, into the hub converter cover 6, and use oil-soluble grease to retain it
- FF. Install as a unit, the converter cover, lockup clutch piston, and related parts (refer to Job Sheet #4)
- GG. Align the balance marks on the cover with the balance marks on the lockup clutch back plate and the converter pump

JOB SHEET #6

- HH. Secure the converter cover with twenty-four nuts 5
- II. Tighten the nuts evenly to 19-23 lb ft torque
- JJ. Install a spacer 4, and then a spacer retainer 3 onto each of the six drive studs on the converter cover

(NOTE: At this point in the procedure, the end play check is necessary if spacer 19 was not installed at buildup; however, the check is recommended even if spacer 19 was installed to verify that proper end play remains after rebuild; refer to Job Sheet #3 for the procedure for checking end play, repeat the procedure, if required, at this point, and use the Spacer Chart in Job Sheet #3 to select the right spacer by number and color; it is not necessary to disassemble the complete converter if another spacer is required at this time; check with your instructor if you have any questions about the correct procedure.)

- KK. Stop at this point and have your instructor check and initial your procedure and safe practice

INSTRUCTOR CHECK: Procedure ☐ Safety ☐ Initials ☐

AUTOMATIC TRANSMISSIONS UNIT V

JOB SHEET #7--DISASSEMBLE, CLEAN, INSPECT, AND REASSEMBLE A MODULATED LOCKUP VALVE ASSEMBLY

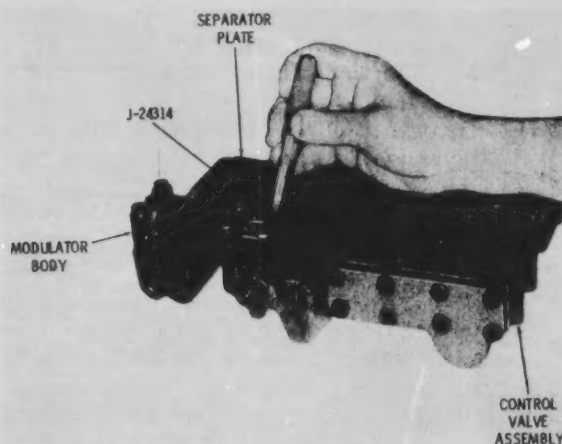
- I. Tools and materials
 - A. Basic hand tools
 - B. Clean shop towels
 - C. Cleaning solvent in a clean container
 - D. Compressed air supply for drying parts
 - E. Appropriate service manual
 - F. Adjusting ring tool
 - G. Safety glasses

- II. Procedure

(NOTE: The following procedure and illustrations are adapted from materials published by Detroit Diesel Allison, © General Motors Corporation, and are reprinted with permission; this procedure may be modified by your instructor to facilitate available equipment.)

- A. Disassemble the modulated lockup valve assembly with the following procedure:

FIGURE 1



1. Mark adjusting ring 7 to indicate its position in relation to pin 3 (Figure 1)

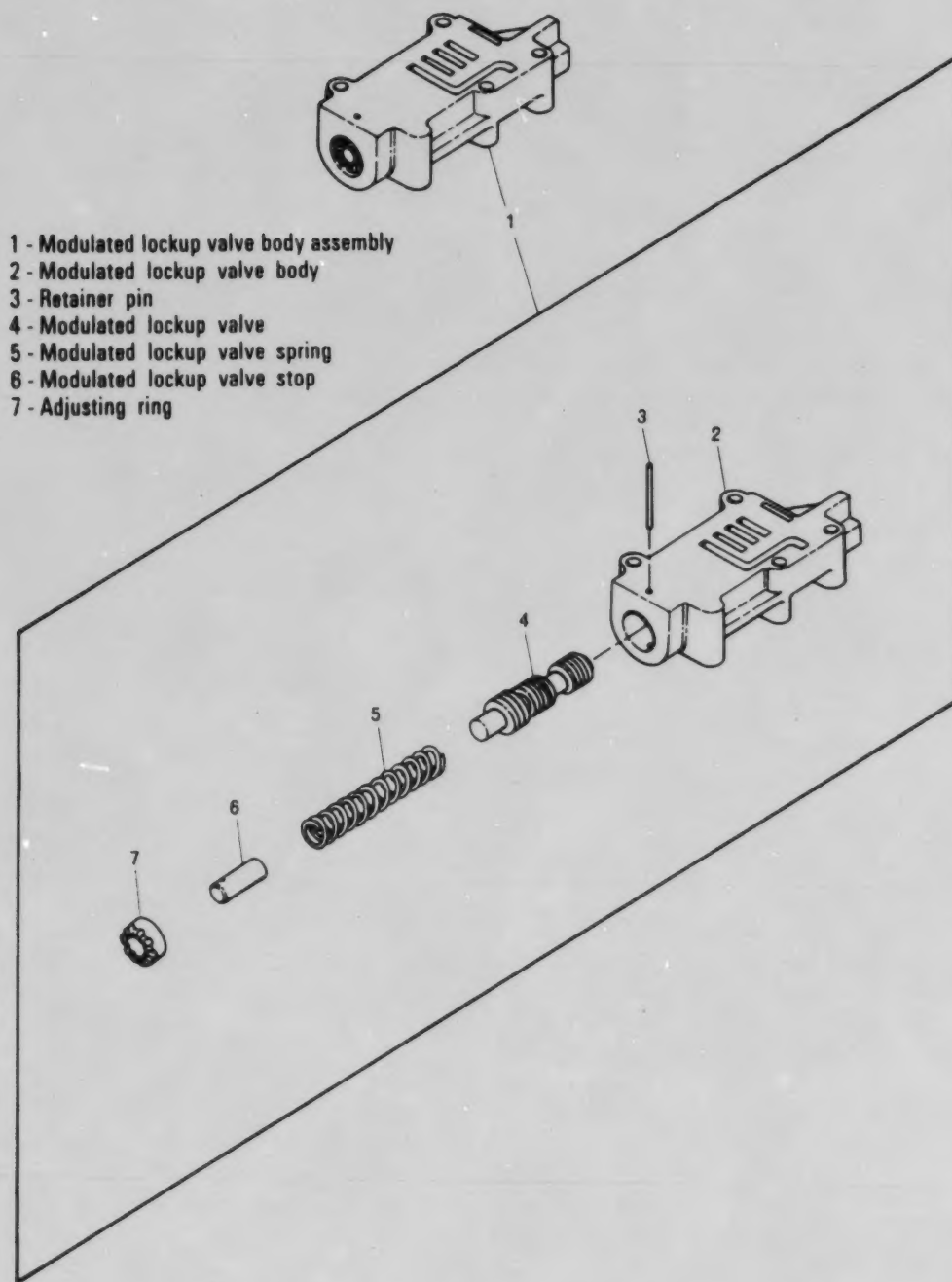
(NOTE: Refer to the parts list and exploded view that accompany this job sheet for parts identification.)

JOB SHEET #7

2. Depress ring 7 with valve body adjusting ring tool J-24314 against spring pressure, and remove pin 3
 3. Remove adjusting ring 7, valve stop 6, spring 5, and valve 4 from valve body 2
 4. Clean and dry parts for inspection and reassembly
 5. Inspect adjusting ring for nicks, distortion, and excessive wear; replace if required
 6. Inspect spring for signs of overheating, permanent set, or wear due to rubbing adjacent parts; replace if required
- B. Stop at this point and have your instructor check and initial your procedure and safe practice
- INSTRUCTOR CHECK: Procedure ☐ Safety ☐ Initials ☐
- C. Reassemble the modulated lockup valve assembly with the following procedure:
1. Install valve 4, smaller diameter first, into valve body 2
 2. Install spring 5
 3. Install valve stop 6, undrilled end first, into spring 5
 4. Install adjusting ring 7, flat side first, over valve stop 6, and align the adjusting ring as it was aligned prior to disassembly
 5. Depress ring 7 against spring pressure, and install pin 3 through the holes in valve body 2 and valve stop 6, and into the slot of adjusting ring 7
 6. Inspect adjusting ring to be sure it is aligned with the pin as it was before removal
- D. Stop at this point and have your instructor check and initial your procedure and safe practice

INSTRUCTOR CHECK: Procedure ☐ Safety ☐ Initials ☐

JOB SHEET #7--PARTS LIST AND EXPLODED VIEW FOR
MODULATED LOCKUP VALVE ASSEMBLY



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AUTOMATIC TRANSMISSIONS UNIT V

JOB SHEET #8--DISASSEMBLE, CLEAN, INSPECT, AND REASSEMBLE A LOW SHIFT VALVE ASSEMBLY

I. Tools and materials

- A. Basic hand tools
- B. Clean shop towels
- C. Cleaning solvent in a clean container
- D. Compressed air supply for drying parts
- E. Appropriate service manual
- F. Safety glasses

II. Procedure

(NOTE: The following procedure and illustrations are adapted from materials published by Detroit Diesel Allison, © General Motors Corporation, and are reprinted with permission; this procedure may be modified by your instructor to facilitate available equipment.)

A. Disassemble the low shift valve assembly with the following procedure:

1. Mark the location of adjusting ring 14 in relation to pin 6

(NOTE: Refer to the parts list and exploded view that accompany this job sheet for parts identification.)

2. Remove retainer pins 5 and 6 from body 4 while applying pressure to adjusting ring 14 and valve stop 9
3. Remove adjusting ring 14, washer 13, valve stop 12, valve spring 11, and low shift singal valve 10 from body 4
4. Remove valve stop 9, spring 8, and low shift relay valve 7
5. Clean and dry parts for inspection and reassembly
6. Inspect valves, springs, and bores for signs of overheating or wear; replace as needed

JOB SHEET #8

- B. Stop at this point and have your instructor check and initial your procedure and safe practice

INSTRUCTOR CHECK: Procedure ☐ Safety ☐ Initials ☐

- C. Reassemble the low shift valve assembly with the following procedure:

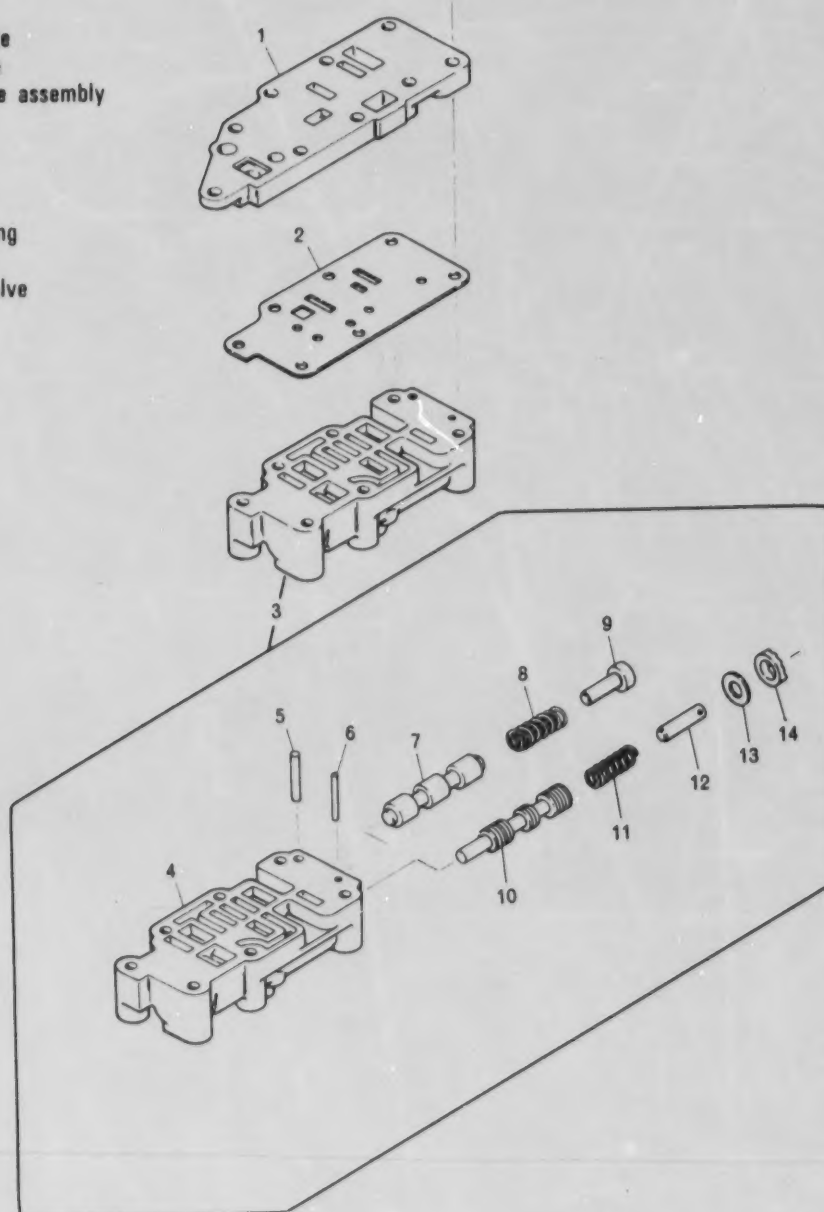
1. Install low shift relay valve 7 into the longer bore of valve body 4
2. Install spring 8 and valve stop 9 into the same bore
3. Depress stop 9 and install pin 5 into body 4
4. Install low shift signal valve 10, stem end first, into the remaining valve bore
5. Install spring 11, stop 12, and washer 13
6. Install adjusting ring 14, flat side first into the valve bore
7. Align the hole in valve stop 12 and the slot in ring 14 with the hole in valve body 4
8. Install retainer pin 6, and be sure adjusting ring 14 is aligned with the pin as it was before removal

- D. Stop at this point and have your instructor check and initial your procedure and safe practice

INSTRUCTOR CHECK: Procedure ☐ Safety ☐ Initials ☐

JOB SHEET #8--PARTS LIST AND EXPLODED VIEW FOR LOW SHIFT
VALVE BODY ASSEMBLY

- 1 - Oil transfer plate
- 2 - Separator plate
- 3 - Low shift valve assembly
- 4 - Valve body
- 5 - Retainer pin
- 6 - Retainer pin
- 7 - 1-2 shift valve
- 8 - Shift valve spring
- 9 - Valve stop
- 10 - 2-1 inhibitor valve
- 11 - Valve spring
- 12 - Valve stop
- 13 - Washer
- 14 - Adjusting ring



AUTOMATIC TRANSMISSIONS UNIT V

JOB SHEET #9--DISASSEMBLE, CLEAN, INSPECT, AND REASSEMBLE A CONTROL VALVE BODY ASSEMBLY

- I. Tools and materials
 - A. Basic hand tools
 - B. Clean shop towels
 - C. Clean solvent in a clean container
 - D. Compressed air supply for drying parts
 - E. Appropriate service manual
 - F. 100 foot-pound torque wrench
 - G. Oil-soluble grease
 - H. Rubber band or soft wire
 - I. Plastic bag or wrap
 - J. Safety glasses

- II. Procedure

(NOTE: The following procedure and illustrations are adapted from materials published by Detroit Diesel Allison, © General Motors Corporation, and are reprinted with permission; this procedure may be modified by your instructor to facilitate available equipment.)

- A. Disassemble the control valve body assembly with the following procedure:

- 1. Place valve assembly 1 on a work table with modulator valve body 47 upward

(NOTE: Refer to the parts list and exploded view that accompany this job sheet for parts identification.)

- 2. Remove three bolts 40 from the modulator body and remove the modulator body

(NOTE: The valve body assembly contains a number of springs that can be mistakenly interchanged; since the calibration of the valve body functions will be lost if the springs are not reinstalled in the same locations from which they are removed, it is recommended that each spring be tagged as it is removed and listed according to its identifying part number in the exploded view; notes or sketches should be made of pins and adjusting rings too; these must also be reinstalled in their original positions for the original calibration of the valve body to be maintained.)

JOB SHEET #9

3. Remove retaining pin 48 from modulator body 47 while applying pressure to adjusting ring 41, then remove the adjusting ring
4. Remove valve stop 42, washer 43, spring 44, modulator valve 45, and actuator pin 46

(NOTE: On Allison models, only those models equipped with modulated lockup use separator plate 39; all others use plate 38.)

5. Remove separator plate 38 or 39

(NOTE: Later MT 650, 653 models include a slot in the separator plate, that engages the flared end of the retaining pin 33; the separator plate must be slid lengthwise to disengage it from pin 33.)

6. Remove priority valve 4, spring 3, and stop 2

(NOTE: On later model MT 650, 653 models, a 1/4-inch ball 49 is used; note the location of the ball in the valve body before removal.)

7. Place control body 50 on a work table, flat side down

(CAUTION: Trimmer valve corner 71 is spring loaded and must be restrained while the bolts are being removed.)

8. Remove eight bolts 72 from trimmer valve cover 71
9. Remove trimmer valve cover 71, and valve stops 55, 60, 65, and 70
10. Remove springs 53, 54, 58, 59, 63, 64, 68, and 69

(NOTE: Springs 54, 59, 64, and 69 are used on Allison models with serial numbers after 13800.)

11. Remove trimmer plugs 52, 57, 62, and 67
12. Remove trimmer valves 51, 56, 61, and 66

(NOTE: Valve stop 76 and spacer 79 are spring loaded and must be restrained while pins 73 are being removed.)

13. Remove two retainer pins 73 from the control valve
14. Remove valve stop 76 and spacer 79
15. Remove relay valve springs 75 and 78, and relay valves 74 and 77

(NOTE: Adjusting rings 9 and washer 8 are applicable on Allison models after serial number 66939; record location of the adjusting ring in relation to retaining pin 11 before removal.)

16. Depress adjusting ring 9 or spacer (earlier models)

JOB SHEET #9

17. Remove pin 11, ring 9 or spacer, washer 8 (if used), valve stop 7, spring 6, and valve 5
 18. Remove selector valve 10
 19. Compress adjusting rings 16, 2, and 28, and remove retainer pins 17, 23, and 29
 20. Remove the adjusting rings
 21. Remove valve stops 15, 21, and 27
 22. Remove springs 14, 20, and 26
 23. Remove modulator valves 13, 19, and 25
 24. Remove shift valves 12, 18, and 24
 25. Compress relay valve stop 32 and remove retainer pin 33
 26. Remove valve stop 32, valve spring 31, and relay valve 30
 27. Depress trimmer regulator valve stop 37 and remove retainer pin 34
 28. Remove valve stop 37, spring 36, and valve 35
 29. Clean and dry parts for inspection and reassembly
 30. Inspect valves, springs, and bores for signs of overheating or wear; replace as needed
- B. Stop at this point and have your instructor check and initial your procedure and safe practice

INSTRUCTOR CHECK: Procedure ☐ Safety ☐ Initials ☐

- C. Reassemble the control valve body assembly with the following procedure:

1. Install valve 5 into its bore in valve body 50

(NOTE: For reassembly you should refer not only to the parts list and exploded view but also to the cross-section view that accompanies this job sheet; also, double check the position of all components, configuration of valves and plugs, and the identification of all springs before installation; refer to the spring chart from the manufacturer's service manual, and make sure that all valves, when dry, move freely, by their own weight in the bore.)

2. Install spring 6, valve stop 7, washer 8, and adjusting ring 9 into the same bore

(NOTE: This step applies to late models; on earlier models, install spring 6, valve stop 7, and a spacer into the same bore.)

JOB SHEET #9

3. Depress the adjusting ring or spacer against spring pressure and install pin 11

(NOTE: The location of pin 11 should have been sketched or noted during disassembly.)

4. Install pin 11 through hole in valve stop 7; on earlier models, depress spacer and install pin 11

5. Install valve 12, shorter land first, into valve body 50

(NOTE: Remember to refer to the cross-section illustration for proper parts replacement reference.)

6. Into the same bore, install valve 13, smaller end first

7. Install spring 14, valve stop 15, and adjusting ring 16

8. Depress ring 16 against spring pressure and install pin 17 so that it passes through valve stop 15 and retains ring 16

9. Install valve 18, smaller end first, into valve body 50; refer to cross-section (bore C)

10. Into the same bore, install valve 19, smaller end first

11. Install spring 20, valve stop 21, and adjusting ring 22

12. Depress ring 22 against spring pressure and install pin 23 so that it passes through valve stop 21 and retains ring 22

13. Install valve 24, smaller end first, into valve body 50; refer to cross-section (bore D)

14. Into the same bore, install valve 25, smaller end first, spring 26, valve stop 27, and adjusting ring 28

15. Depress adjusting ring 28 against spring pressure and install pin 29 so that it passes through valve stop 27 and retains ring 28

16. Install valve 30 into valve body 50; refer to cross-section (bore E)

17. Into the same bore, install spring 31 and valve stop 32

18. Depress valve stop 32 against spring pressure and install pin 33

19. Install valve 35, smaller end first, into valve body 50; refer to cross-section (bore F)

JOB SHEET #9

20. Install trimmer valve 51, open end first, into valve body 50; refer to cross-section (bore G)
21. Into the same bore, install plug 52, springs 53 and 54, and valve stop 55
22. Install trimmer valve 56, open end first, into valve body 50; refer to cross-section (bore H)
23. Into the same bore, install plug 57, springs 58 and 59, and valve stop 60
24. Install trimmer valve 61, open end first, into valve body 50; refer to cross-section (bore I)
25. Into the same bore, install plug 62, springs 63 and 64, and valve stop 65
26. Install trimmer valve 66, open end first, into valve body 50; refer to cross-section (bore K)
27. Into the same bore, install plug 67, springs 68 and 69, and valve stop 70
28. Install cover 71 over springs 53, 58, 63, and 68
29. Force the cover against spring pressure, and install eight 1/4-20 x 5/8-inch bolts 72
30. Tighten the bolts to 9-11 lb ft torque
31. Install valve 74 into valve body 50; refer to cross-section (bore L)
32. Into the same bore, install spring 75 and valve stop 76
33. Depress stop 76 against spring pressure, and install pin 73
34. Install valve 77, larger end first, into valve body 50; refer to cross-section (bore M)
35. Into the same bore, install spring 78 and spacers 79
36. Depress spacer against spring pressure, and install pin 73
37. Install actuator rod 46, smaller end first, into valve body 47; refer to cross-section (bore N)
38. Install valve 45, longer land first, into the same bore
39. Install spring 44, washer 43, valve stop 42, and adjusting ring 41

JOB SHEET #9

40. Depress adjusting ring 41 against spring pressure, and install pin 48 so that it passes through valve stop 42 and retains ring 41
41. Replace ball 49 in its original position, and retain the ball with oil-soluble grease; refer to cross-section, section BB

(NOTE: On some models, this step may not be required.)

42. Install valve stop 2, spring 3, and priority valve 4, open end first, into valve body 50; refer to cross-section (bore O)
43. Place separator plates 38 or 39 onto body 40 so the bolt holes align

(NOTE: On later Allison models MT 650 and 653, there is a slot in the separator plate that engages the flared end of pin 33.)

44. Install the assembled modulator valve onto separator plate 38 or 39, and align the bolt holes
45. Install three 1/4-20 x 1 3/4-inch bolts 40 through valve body 47, plates 38 or 39, and into valve body 50
46. Make sure that the plate and valve body are properly aligned so that all valve body mounting bolts will pass through them, then tighten bolts to 9-11 lb ft torque
47. Install selector valve 10, drilled end first, into valve body 50; refer to cross-section (bore P)
48. Secure the valve against dropping out with a rubber band, cord, or soft wire
49. Using adjusting tool J-24314, position adjusting rings 9, 16, 22, 28, and 41 as they were before the valve body was disassembled

- D. Stop at this points and have your instructor check and initial your procedure and safe practice

INSTRUCTOR CHECK: Procedure ☐ Safety ☐ Initials ☐

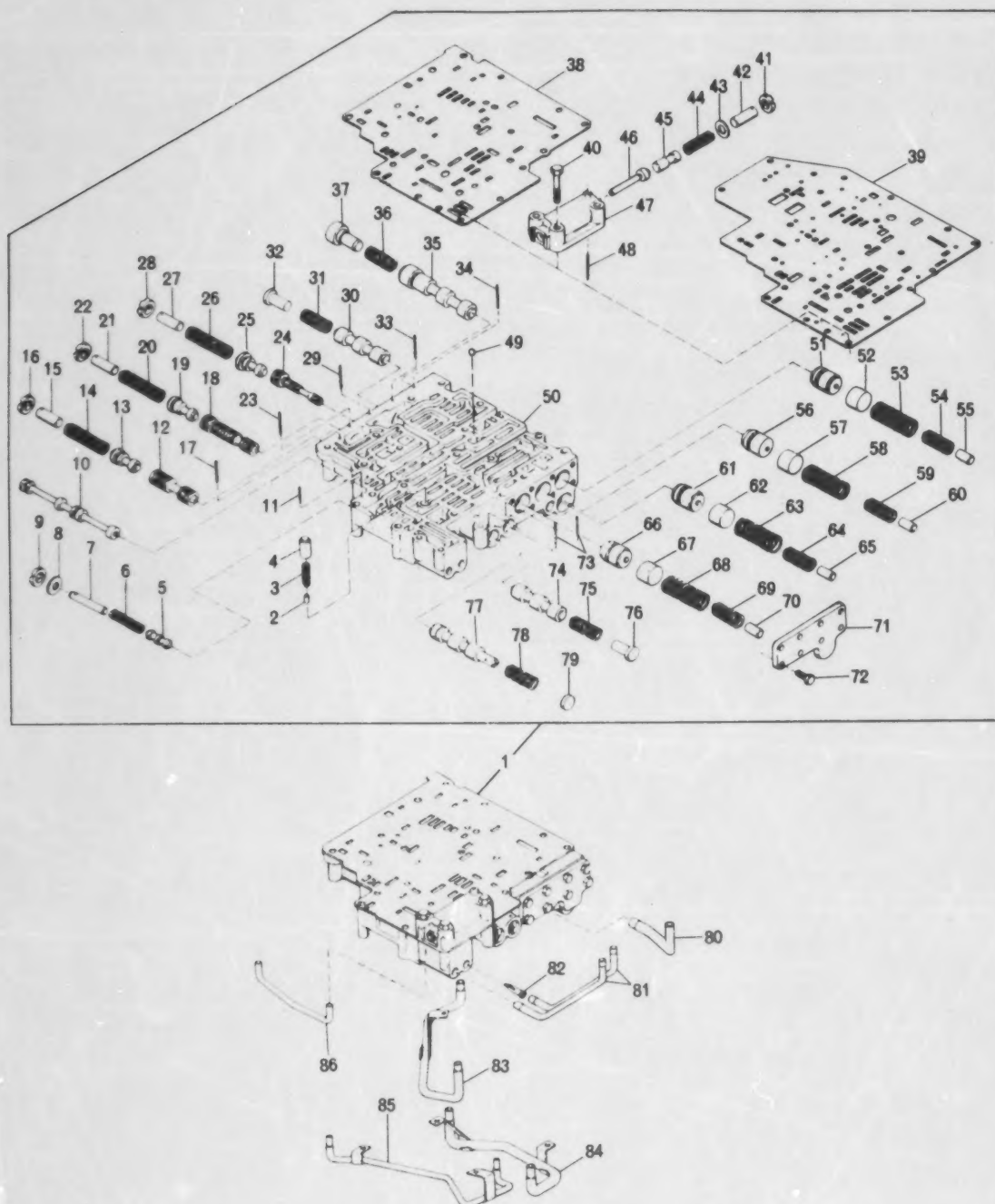
- E. Cover the control valve body assembly with a plastic bag or wrap to protect it from dust, dirt, and moisture if it is not going to be immediately reinstalled

JOB SHEET #9-PARTS LIST FOR CONTROL VALVE BODY ASSEMBLY

- | | | |
|------------------------------------|-----------------------------------|--------------------------------------|
| 1 - Control valve assembly | 31 - Valve spring | 60 - Valve stop |
| 2 - Valve stop pin | 32 - Valve stop (later models) | 61 - Second clutch trimmer valve |
| 3 - Priority valve spring | 33 - Retainer pin | 62 - Trimmer plug |
| 4 - Priority valve | 34 - Retainer pin | 63 - Valve outer spring |
| 5 - Hold regulator valve | 35 - Trimmer regulator valve | 64 - Valve inner spring |
| 6 - Regulator valve spring | 36 - Trimmer regulator spring | (after S/N 13800-MT 650, |
| 7 - Valve stop pin | 37 - Trimmer regulator valve stop | 653; all 640, 643) |
| 8 - Washer | 38 - Separator plate | 65 - Valve stop |
| 9 - Adjusting ring | (non-modulated lockup) | 66 - Fourth clutch trimmer valve |
| 10 - Selector valve | 39 - Separator plate | 67 - Trimmer plug |
| 11 - Retainer pin | (modulated lockup) | 68 - Valve outer spring |
| 12 - 2-3 shift valve (MT 650, 653) | 40 - Bolt, 1/4-20 x 1 3/4 (3) | 69 - Valve inner spring |
| 1-2 shift valve (MT 640, 643) | 41 - Adjusting ring | (after S/N 13800) |
| 13 - Shift modulator valve | 42 - Valve stop | 70 - Valve stop |
| 14 - Shift valve spring | 43 - Washer | 71 - Trimmer valve cover |
| 15 - Valve stop | 44 - Valve spring | 72 - Bolt, 1/4-20 x 5/8 (8) |
| 16 - Adjusting ring | 45 - Modulator valve | 73 - Retainer pin (2) |
| 17 - Retainer pin | 46 - Modulator valve actuator pin | 74 - 3-4 relay valve (MT 650, 653) |
| 18 - 3-4 shift valve (MT 650, 653) | 47 - Modulator valve body | 2-3 relay valve (MT 640, 643) |
| 2-3 shift valve (MT 640, 643) | 48 - Retainer pin | 75 - Valve spring |
| 19 - Shift modulator valve | 49 - Check ball (after S/N 47284, | 76 - Valve stop (later models) |
| 20 - Shift valve spring | MT 650, 653 only) | 77 - 2-3 relay valve (MT 650, 653) |
| 21 - Valve stop | 50 - Control valve body | 1-2 relay valve (MT 640, 643) |
| 22 - Adjusting ring | 51 - Third clutch trimmer valve | 78 - Valve spring |
| 23 - Retainer Pin | 52 - Trimmer plug | 79 - Spacer |
| 24 - 4-5 shift valve (MT 650, 653) | 53 - Valve outer spring | 80 - First clutch tube (MT 640, 643) |
| 3-4 shift valve (MT 640, 643) | 54 - Valve inner spring | 81 - Governor tube (2) |
| 25 - Modulator valve | (after S/N 13800) | *82 - Governor screen assembly |
| 26 - Valve spring | 55 - Valve stop | 83 - Trimmer tube (MT 650, 653) |
| 27 - Valve stop | 56 - First clutch trimmer valve | 84 - Low and first feed tube |
| 28 - Adjusting ring | 57 - Trimmer plug | (MT 650, 653) |
| 29 - Retainer pin | 58 - Valve outer spring | 85 - Drive-1 tube (MT 650, 653) |
| 30 - 4-5 relay valve (MT 650, 653) | 59 - Valve inner spring | 86 - Forward regulator tube |
| 3-4 relay valve (MT 640, 643) | (after S/N 13800-MT 650, | (MT 650, 653) |
| | 653; all 640, 643) | |

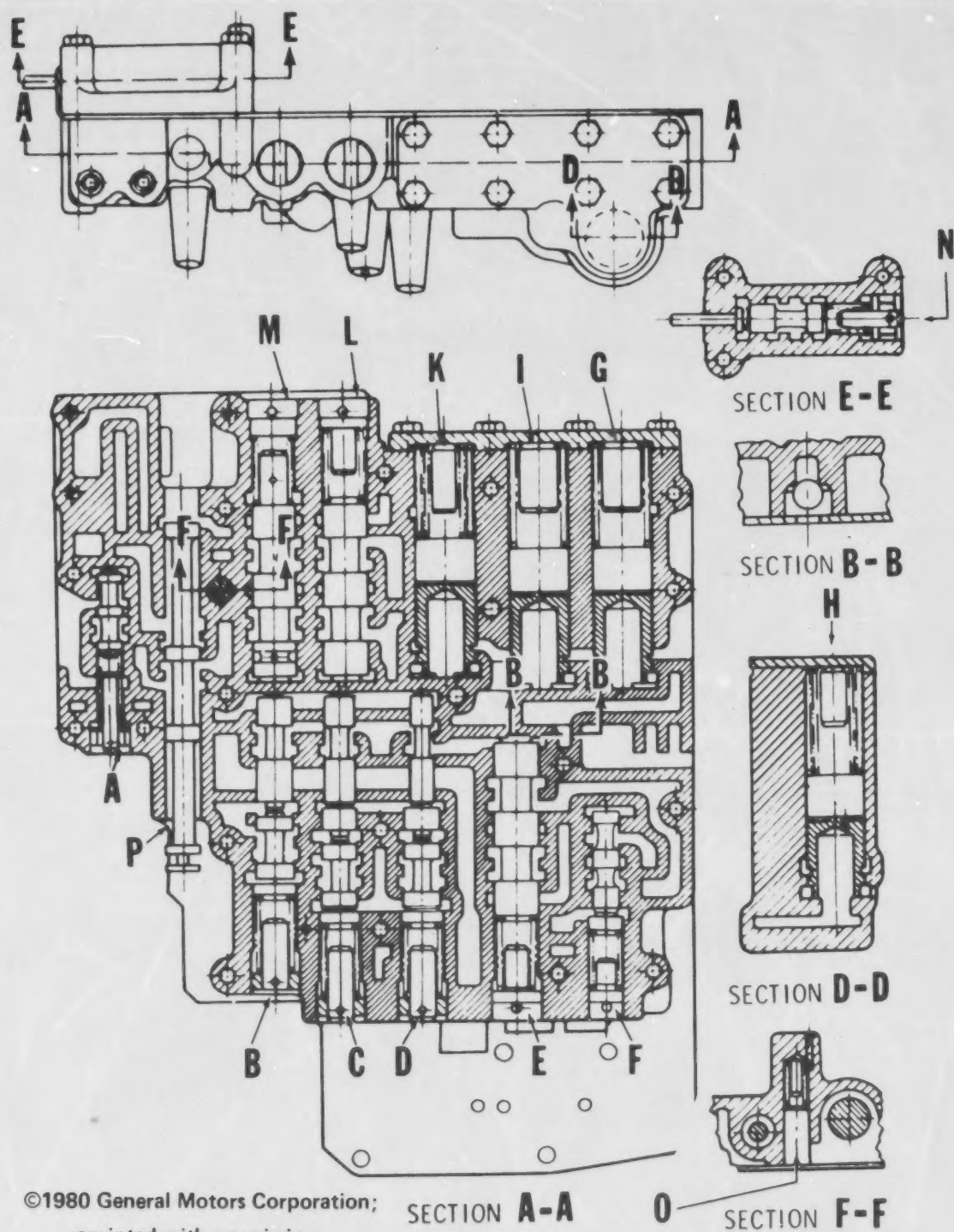
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JOB SHEET #9-EXPLODED VIEW OF CONTROL VALVE BODY ASSEMBLY



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JOB SHEET #9-CROSS-SECTION, CONTROL VALVE BODY ASSEMBLY



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SECTION A-A

SECTION F-F

AUTOMATIC TRANSMISSIONS UNIT V

JOB SHEET #10--DISASSEMBLE, CLEAN, INSPECT, AND REASSEMBLE AN OIL PUMP AND FRONT SUPPORT ASSEMBLY

- I. Tools and materials
 - A. Basic shop tools
 - B. Clean shop towels
 - C. Cleaning solvent in a clean container
 - D. Compressed air supply for drying parts
 - E. Valve pin remover
 - F. Slide hammer
 - G. Lockup spring compressor
 - H. Bushing installer
 - I. Oil seal installer and driver handle
 - J. Nonhardening sealer
 - K. High-temperature sealer
 - L. Straightedge
 - M. Thickness gauge for gear/oil pump clearance
 - N. Centering band
 - O. Bearing installer and driver handle
 - P. Valve spring compressor
 - Q. Valve pin installer
 - R. Oil-soluble grease
 - S. Appropriate service manual
 - T. Safety glasses

- II. Procedure

(NOTE: The following procedure and illustrations are adapted from materials published by Detroit Diesel Allison, © General Motors Corporation, and are reprinted with permission; this procedure may be modified by your instructor to facilitate available equipment.)

JOB SHEET #10

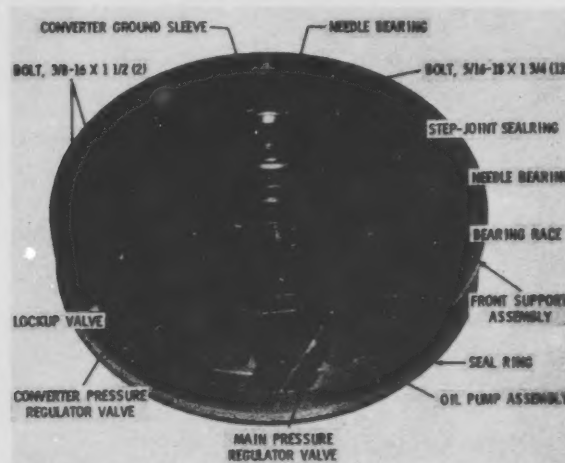
A. Disassemble the oil pump and front support assembly with the following procedure:

1. Place oil pump and support assembly on a work table, support side upward
2. If not previously removed, remove the two step-joint sealrings, the needle bearing, and bearing race from the hub of the front support (Figure 1)
3. Remove oil pump sealring 3

(NOTE: Refer to the parts list and exploded view that accompany this job sheet for parts identification.)

4. Remove the needle bearing from the bore of the converter ground sleeve only if replacement is necessary (Figure 1)

FIGURE 1

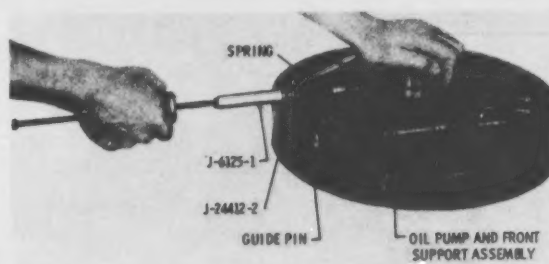


5. If parts replacement is necessary, install valve pin remover J-24412-2 onto the head of the converter regulator valve guide pin

JOB SHEET #10

6. Attach slide hammer J-6125-1 to the valve pin remover tools and remove the guide pin, valve spring, and regulator valve (Figure 2)

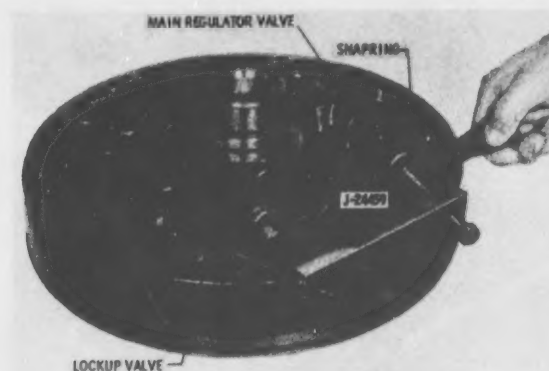
FIGURE 2



7. Attach the main regulator and lockup spring compressor J-24459 to the front support (Figure 3)
8. Tighten the compressor screws, removing all force from the retaining snaprings, and remove both snaprings (Figure 3)

(NOTE: The main pressure regulator valve spring is under approximately 65 pounds compression.)

FIGURE 3



9. Carefully loosen the screws on the spring compressor until it can be removed from the front support
10. Remove valve stops 11 and 18, valve springs 12 and 19, regulator valve 13, and lockup valve 20

JOB SHEET #10

11. Inspect orifice plug in main regulator valve assembly 13; if it is loose, damaged, or distorted, replace regulator valve assembly 13

(NOTE: Current Allison models do not include an orifice plug.)

12. Remove the fourteen bolts that hold the oil pump and the front support together (Figure 1)
13. Separate front support assembly 23 from oil pump body and gear assembly 4
14. Do not remove ground sleeve 25 from front support 26; if relative movement is apparent, replace bearing and front support assembly 23; if the ground sleeve is damaged, replace front support assembly 23
15. If replacement of parts is necessary, remove plug 27 from the circumference of support 26
16. Remove oil pump gears 8 and 9 from oil pump body 7
17. If body 7 or gear 8 or 9 are damaged, replace oil pump assembly 4
18. Remove oil seal 2 from oil pump body 7
19. Remove bushing 6, if damaged, from body 7

(NOTE: Allison models after serial number 49489 do not require bushing 6, models prior to that serial number do.)

20. Clean and dry parts for inspection and reassembly
 21. Inspect all parts for damage or excessive wear
- B. Stop at this point and have your instructor check and initial your procedure and safe practice

INSTRUCTOR CHECK: Procedure ☐ Safety ☐ Initials ☐

- C. Reassemble the oil pump and front support assembly with the following procedure:

1. Install a new bushing 6 if the old one was removed
2. Position the bushing joint (spitline) so that it is within a 10 to 12 o'clock position when viewed from the front of the oil pump body
3. Use installer J-24474 to install the bushing to proper depth which should be flush with, to 0.010 inch below, the area adjacent to the installed bearing
4. If oil seal 2 was removed from oil pump body 7, install a new one

JOB SHEET #10

5. Place the oil pump body on the work table, flat side down
6. Seat the oil seal on installer J-24449 or J-26912, with the spring loaded lip facing away from the tool
7. Attach driver handle J-24202-4 to the oil seal installer
8. Coat the outside diameter of the oil seal with nonhardening sealant
9. Drive the seal into the pump housing as shown in Figure 4

FIGURE 4



10. Remove the seal installer and apply a high temperature seal lubricant to the inside diameter of the oil seal

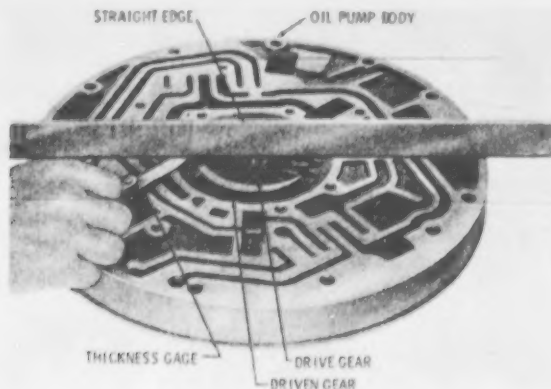
(NOTE: If the above oil seal installer is not available, install the seal, spring loaded lip first, into the seal bore of the oil pump and press the seal to 0.010 - 0.020 inch below the front surface of the pump body; on Allison models after serial number 49489, press the seal to 0.050 - 0.070 inch below the front surface of the pump body.)

11. Position oil pump body 7, flat side up
12. Install drive gear 9 and driven gear 8 into the oil pump body

JOB SHEET #10

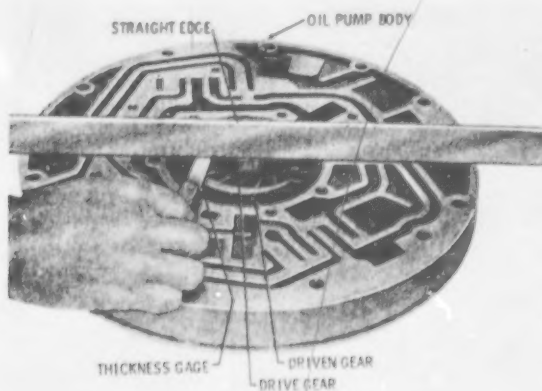
13. Place a straightedge across the surface of the oil pump as shown in Figure 5

FIGURE 5



14. Insert a thickness gauge between the straightedge and the driven gear, then repeat the procedure for the drive gear (Figure 6)

FIGURE 6



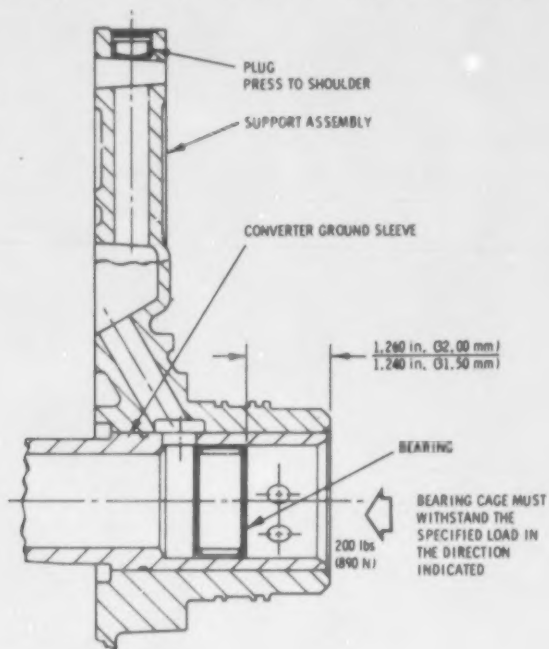
15. Check clearance; if it exceeds 0.0024 inch, the gears and/or pump body are worn
16. Check to see if new gears will reduce the clearance to 0.0024 inch or less; if not, oil pump assembly 4 should be replaced

(NOTE: If several gears are available for trial selection, use those that give the lesser clearance but not less than 0.0005 for drive gear 9, or 0.001 for drive gear 8; use clearance gauge J-26957 for measurements when selecting gears.)

JOB SHEET #10

17. If plug 27 was removed from support 26, replace it
18. Press the plug to the shoulder in the support (Figure 7)

FIGURE 7



19. Place oil pump body and gear assembly 4 on work table, front side down
20. Align the bolt holes in front support assembly 23 with those in assembly 4
21. Install two 5/16-18 x 1 3/4-inch bolts approximately 180 degrees apart
22. Tighten the bolts one or two threads
23. Install centering band J-24461 around the oil pump body and front support assembly (Figure 8)

JOB SHEET #10

24. Install the remaining ten 5/16-18 x 1 3/4-inch bolts, and two 3/8-16 x 1 1/2-inch bolts (Figure 8)

FIGURE 8



25. Check the centering band to insure a secure fit

(NOTE: It is imperative the split line between the pump and the support be perfectly smooth after bolt installation.)

26. Tighten the twelve 5/16-18 bolts to 17-20 lb ft torque, and tighten the 3/8-16 bolts to 36-43 lb ft torque
27. Place needle bearing 28 into ground sleeve 25, with the numbered end of the bearing cage facing up

JOB SHEET #10

28. Using bearing installer J-24457 and driver handle J-8092, drive the bearing into the ground sleeve (Figure 9)

FIGURE 9



(NOTE: If the preceding tools are not available, install the bearing, numbered end of bearing cage up, into the ground sleeve, until the bearing is 1.240 to 1.260 inches from the face of the hub as shown in Figure 7, and remember that the installed bearing must withstand a 200 pound load in the direction indicated in Figure 7 without moving.)

29. Install main regulator valve 13 and lockup valve 20, longer land first, into their proper bores in support 23
30. Install springs 12 and 19, and valve stops 11 and 18 into their proper bores
31. Install main regulator and lockup valve spring compressor J-24459 onto the support as shown in Figure 3
32. Place snaprings 10 and 17 onto the compressor tool screws prior to compressing springs 12 and 19
33. Compress springs 12 and 19 and install snaprings 10 and 17
34. Remove the spring compressor
35. If valve pin 14 was removed, replace it with a new one

JOB SHEET #10

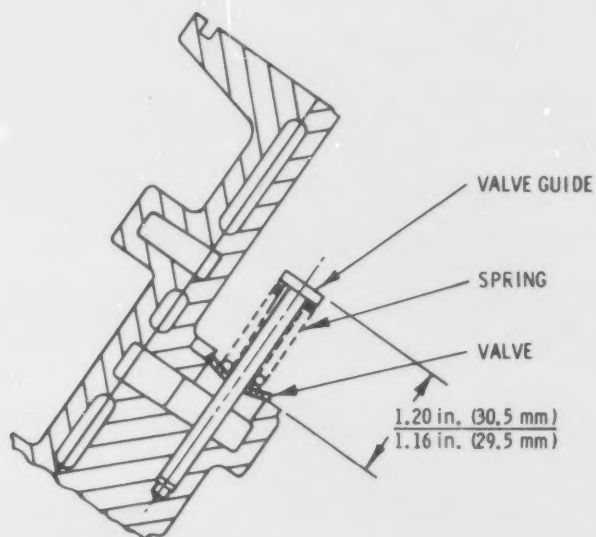
36. Using valve pin installer J-24458, place valve pin 14 into the installer
37. Place spring 15 and valve 16 onto valve pin 14
38. Install the valve pin and components into the front support assembly (Figure 10)

FIGURE 10



39. If valve pin installer J-24458 is not available, install the guide pin and components to extend 1/16 to 1/20 inches above the finished surface (Figure 11)

FIGURE 11



JOB SHEET #10

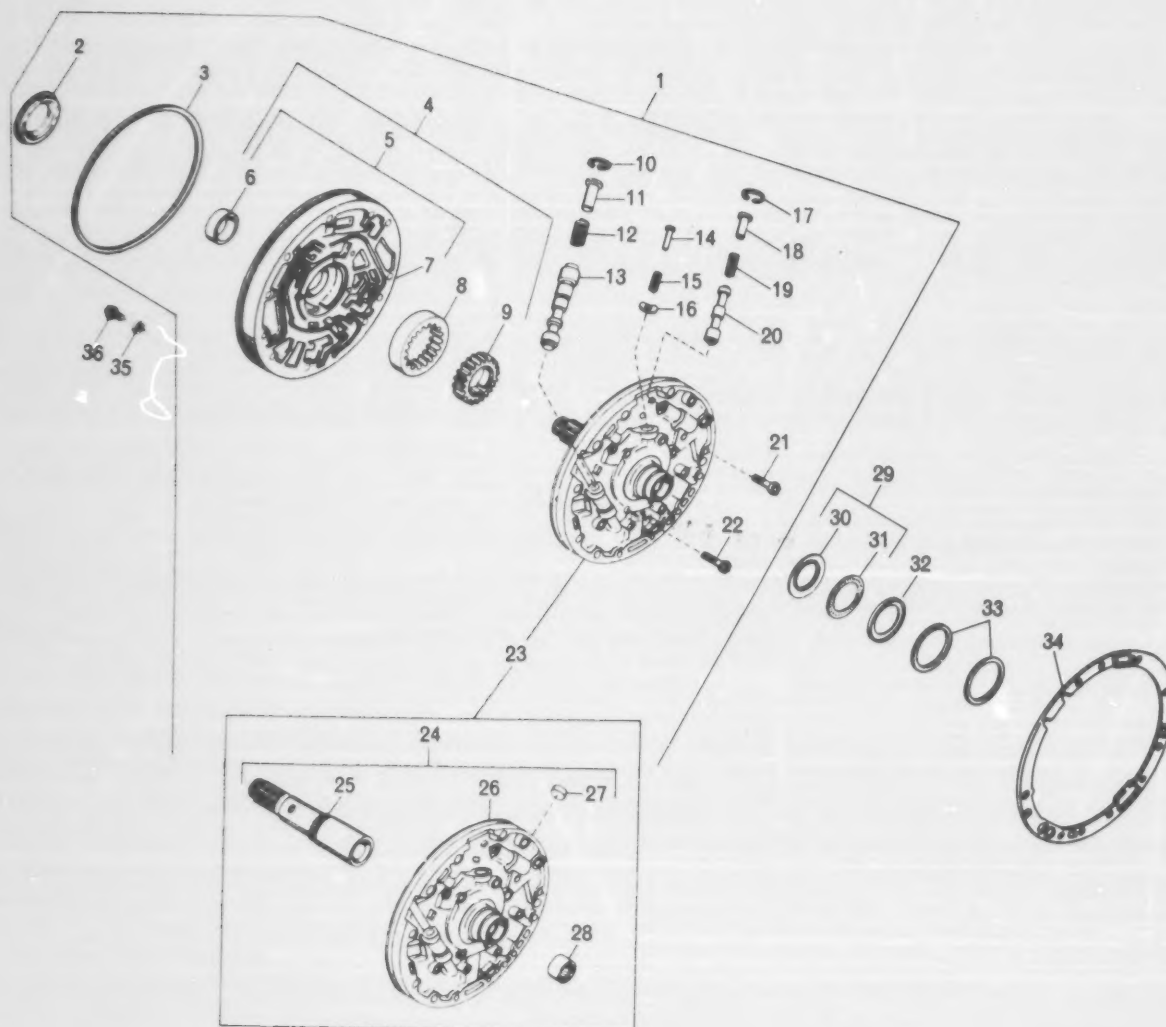
40. Lubricate sealring 3 with an oil-soluble grease and install it into the groove on the outer circumference of the oil pump body
41. Inspect the sealring to be sure it does not twist in the groove
- D. Stop at this point and have your instructor check and initial your procedure and safe practice

INSTRUCTOR CHECK: Procedure ☐ Safety ☐ Initials ☐

JOB SHEET #10--PARTS LIST FOR OIL PUMP AND
FRONT SUPPORT ASSEMBLY

- | | |
|--|--|
| 1 - Oil pump and front support assembly | 19 - Valve spring |
| 2 - Oil seal | 20 - Lockup valve |
| 3 - Sealring | 21 - Self-locking bolt, 3/8-16 x 1-1/2 (2) |
| 4 - Oil pump assembly | 22 - Self-locking bolt, 5/16-18 x 1 3/4 (12) |
| 5 - Pump body and bushing assembly
Before S/N 49490 | 23 - Valve and front support assembly |
| 6 - Bushing - Before S/N 49490 | 24 - Front support assembly |
| 7 - Pump body | 25 - Converter ground sleeve |
| 8 - Pump driven gear | 26 - Front support |
| 9 - Pump drive gear | 27 - Plug |
| 10 - Snapring | 28 - Needle bearing assembly |
| 11 - Valve stop | 29 - Roller bearing assembly |
| 12 - Valve spring | 30 - Bearing race |
| 13 - Main pressure regulator valve | 31 - Bearing |
| 14 - Valve guide | 32 - Bearing race |
| 15 - Valve spring | 33 - Sealring (2) |
| 16 - Converter pressure regulator valve | 34 - Gasket |
| 17 - Snapring | 35 - Washer (12) |
| 18 - Valve stop | 36 - Bolt, 3/8-16 x 3-3/8 (12) |

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JOB SHEET #10--EXPLODED VIEW OF OIL PUMP
AND FRONT SUPPORT ASSEMBLY

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AUTOMATIC TRANSMISSIONS UNIT V

JOB SHEET #11--DISASSEMBLE, CLEAN, INSPECT, AND REASSEMBLE A FORWARD CLUTCH AND TURBINE SHAFT

- I. Tools and materials
 - A. Basic shop tools
 - B. Clean shop towels
 - C. Cleaning solvent in a clean container
 - D. Compressed air supply for drying parts
 - E. 20 pieces of 3/32 x 0.020 x 3 steel shim stock
 - F. Press
 - G. Compressor
 - H. Forward clutch clearance gauge
 - I. Oil-soluble grease
 - J. Appropriate service manual
 - K. Safety glasses

- II. Procedure

(NOTE: The following procedure and illustrations are adapted from materials published by Detroit Diesel Allison, © General Motors Corporation, and are reprinted with permission; this procedure may be modified by your instructor to facilitate available equipment.)

- A. Disassemble the forward clutch and turbine shaft with the following procedure:
 - 1. Remove sealing 3 from the housing and shaft assembly

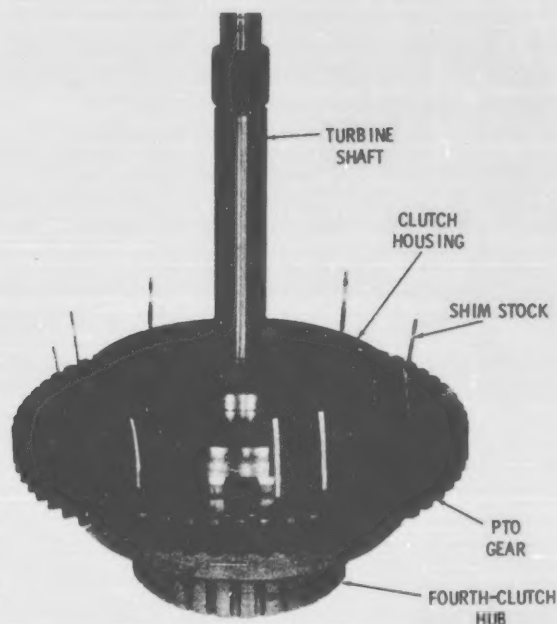
(NOTE: Refer to the parts list and exploded view that accompany this job sheet for parts identification.)

JOB SHEET #11

2. Remove the PTO gear by compressing the snapping, located within the gear, and sliding the gear from the housing

(NOTE: Figure 1 illustrates a model that does not include centrifugal valve components 6 through 9; the procedures that follow in steps 3 through 8 apply to all models; however, when the centrifugal valve is included, the assembly must be positioned shaft downward.)

FIGURE 1

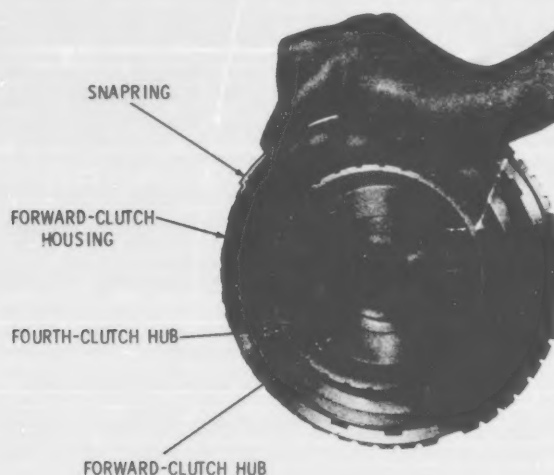


3. To compress the snapping, insert 10 pieces of steel shim stock, $3/32 \times 0.020 \times 3$, between the snapping and the PTO gear
4. To accomplish this, locate the snapping gap, and at the cutout nearest the gap, press the snapping into the groove in the housing
5. Slip a piece of ship stock between the snapping and the inner ends of the splines of the PTO gear, and repeat the operation at the other side of the snapping gap
6. Work at each opening where there is a missing spline to compress the snapping, and insert the remaining pieces of shim stock at approximately 3-inch increments
7. Slide the gear from the housing and remove the snapping

JOB SHEET #11

8. If the gear does not slip easily, check for a break in the light that can be seen between the gear and housing, and work to depress the snapping in that area
9. Remove the snapping that retains the fourth clutch hub in the forward clutch housing (Figure 2)

FIGURE 2

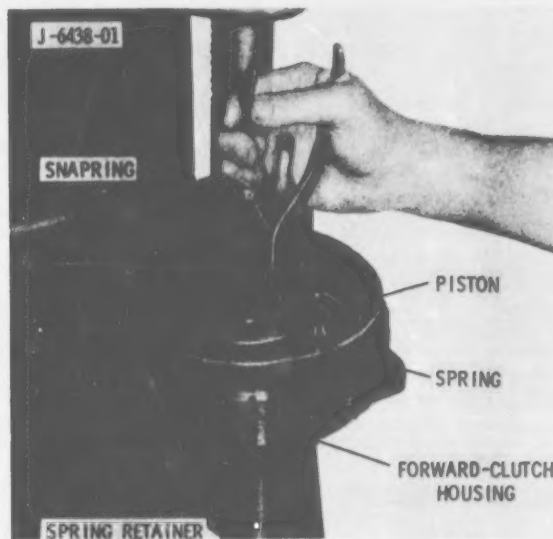


10. Remove the fourth clutch hub and the forward clutch hub from the housing
11. Remove bearing races 18 and 20, and bearing 19; these bearing components may adhere to either forward clutch hub 21 or the hub of forward clutch housing 4
12. Remove five internal-splined plates 23 and five external-tanged plates 22 from the forward clutch housing

JOB SHEET #11

13. Place the housing and shaft assembly in a press as shown in Figure 3

FIGURE 3



14. Using compressor J-6438-01, depress the spring retainer and remove the retainer snapping
15. Remove the retainer, piston return spring, and piston
16. Remove sealring 13 from the piston and sealring 12 from housing
17. Remove the balls 5 from housing and shaft assembly 4, only if replacement is necessary; if necessary, clear the bores of staked metal and remove the balls
18. On Allison models after serial number 49489, remove pin 9, plug 6, valve spring 7, and valve 8 from the outer circumference of forward clutch housing assembly 4
19. Clean and dry parts for inspection and reassembly
20. Inspect splined parts for stripped, twisted, chipped, or burred splines

JOB SHEET #11

21. Inspect snaprings for nicks, distortion, and excessive wear
22. Inspect friction-faced steel plate for burrs, embedded metal particles, severely pitted faces, or excessive wear
23. Replace parts that cannot be corrected with a soft honing stone

B. Stop at this point and have your instructor check and initial your procedure and safe practice

INSTRUCTOR CHECK: Procedure ☐ Safety ☐ Initials ☐

C. Reassemble the forward clutch and turbine shaft with the following procedure:

1. Inspect centrifugal valve parts 6, 7, 8, and 9 for damage and replace with new parts if needed

(NOTE: This step applies to all models with centrifugal pumps; when replacement parts are required, be sure the color code is the same as the part replaced because all three parts, 6, 7, and 8, must be identically coded.)

2. Install centrifugal valve 8, conical end first, into its bore in forward clutch housing 4
3. Place spring 7 inside the valve
4. Compress the spring with plug 6 and retain the spring and plug with pin 9
5. If balls 5 were removed, replace them
6. Place each ball in its bore, and stake each bore at three equally spaced places

(NOTE: Each bore is properly staked when the ball has at least 0.020-inch axial movement and when the ball is retained by the stakes when a 30 lb load is applied against the ball.)

7. Establish clutch clearance before completing the assembly, using either the direct measurement method or stack dimension computation

(NOTE: The method for direct measurement is given in this procedure; stack dimension computation for clutch clearance is covered in the service manual.)

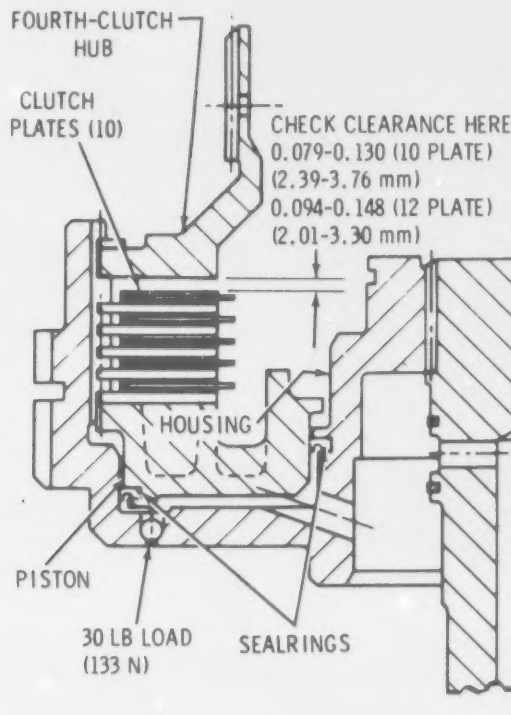
8. Position the clutch housing and shaft assembly, shaft downward, on a work table
9. Lubricate and install the piston sealrings into their grooves in the housing hub and piston

JOB SHEET #11

10. Make sure that the sealing lips face toward the oil pressure side of the piston, and install the piston into the housing (Figure 4)

(CAUTION: If either sealing is installed incorrectly, the forward clutch will not operate properly.)

FIGURE 4



11. Alternately install the five external-tanged plates and five internal-splined plates
12. Install the fourth clutch driving hub and retain it with the snapping
13. Hold the fourth clutch driving hub firmly against the snapping and, using forward clutch clearance gauge J-26913, check the clearance between the fourth clutch driving hub and the internal-splined clutch plate
14. Check clearance for forward clutch to see that the clearance is 0.079-0.130 inch

(NOTE: When clearance is achieved, the first step of gauge J-26913 will fit between the hub and plate, but the second step of the gauge will not.)

JOB SHEET #11

15. When the second stage of the gauge will fit, clearance is excessive and the thinner clutch plates should be replaced with new ones
16. If the clearance is still excessive after all ten plates and fourth clutch drive hub have been replaced, a thicker piston is required
17. When the first stage of the gauge will not fit, clearance is insufficient and a thinner piston is required

(NOTE: Refer to manufacturer's parts catalog for proper piston selection.)

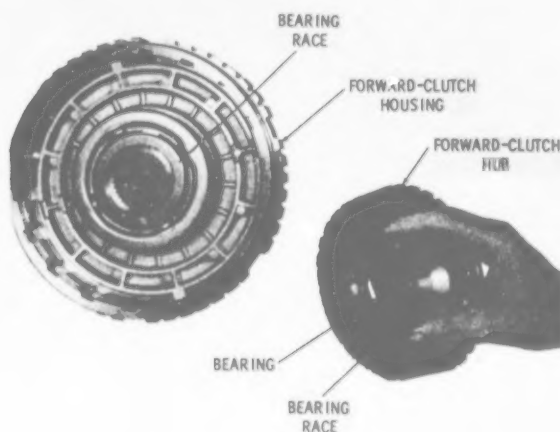
18. Remove the snapping that retains the fourth clutch driving hub, and remove the hub
19. Remove the forward clutch plates
20. Place the clutch housing and shaft assembly, and assembled piston on a press bed as shown in Figure 3
21. Install the piston return spring and spring retainer, and position the snapping on the hub
22. Using compressor J-6438-01, depress the spring retainer sufficiently to install the snapping into its groove in the housing hub

JOB SHEET #11

23. Return the subassembly to the work table, and install the bearing race, outer lip first, onto the hub of the forward clutch housing (Figure 5)

(CAUTION: The use of oil-soluble grease to retain bearing races 18 and 20, and bearing assembly 19 is very important; dislocation or off-centering of either race or the bearing assembly, before the forward clutch assembly is installed into the transmission will prevent proper installation, and extensive damage could result from improper assembly.)

FIGURE 5

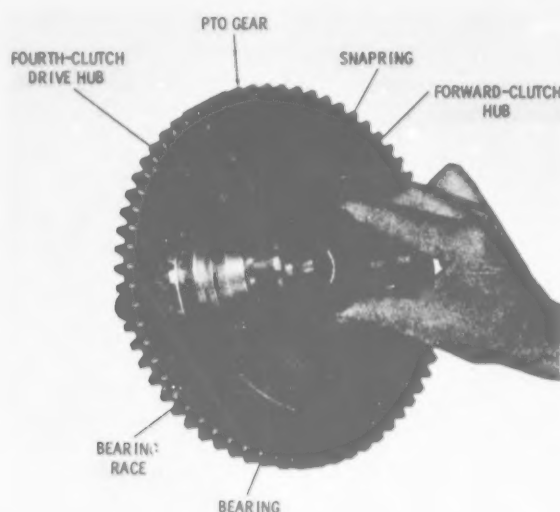


24. Install the other bearing race, flat side first, onto the inner hub of the forward clutch hub (Figure 5) and install the bearing onto the race
25. Retain the bearing with oil-soluble grease
26. Position the clutch housing and shaft, shaft downward, on a work table
27. Place the forward clutch hub, outer splines first, onto the hub of the forward clutch housing
28. Install the ten clutch plates, starting with an external-tanged plate

JOB SHEET #11

29. Install the fourth clutch driving hub, and retain it with the snapping (Figure 6)

FIGURE 6

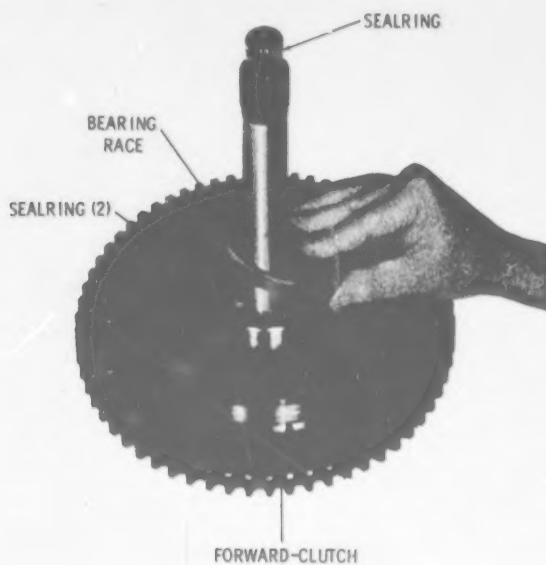


30. Install the PTO gear snapping onto the forward clutch housing
31. Install the PTO gear, chamfered inside diameter first, from the rear of the clutch housing
32. Slide the gear onto the housing until the snapping engages its mating groove in the gear
33. Install the bearing race, flat side first, and bearing onto the hub of the forward clutch hub (Figure 6)
34. Use oil-soluble grease to retain the bearing components during the rest of the reassembly procedure

JOB SHEET #11

35. Invert the assembly and install two sealrings at the base of the shaft and one near the end of the shaft (Figure 7)

FIGURE 7



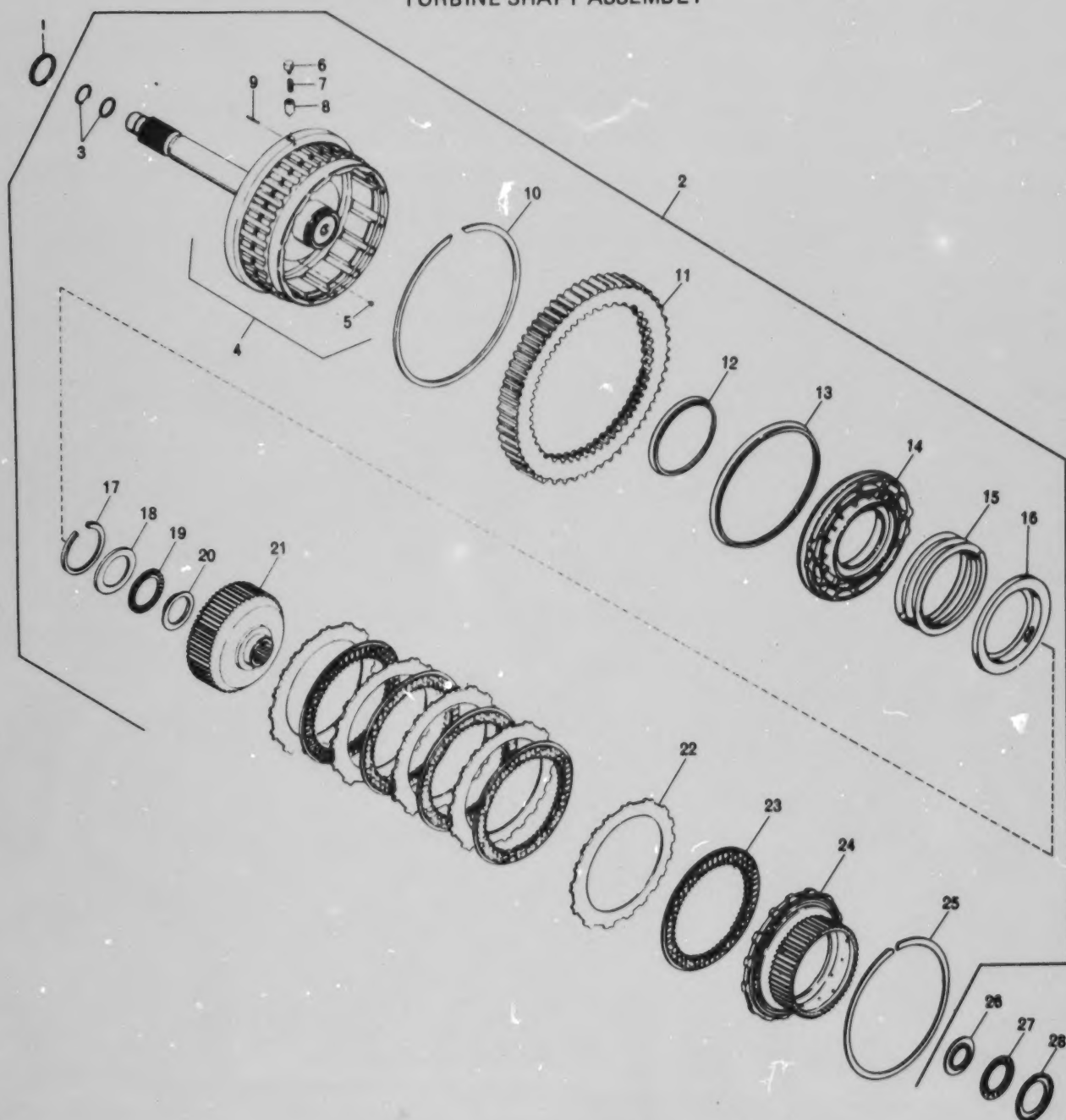
36. Retain the sealrings with oil-soluble grease
37. Install the bearing race, outer lip first, onto the hub of the clutch housing
38. Retain the race with oil-soluble grease
- D. Stop at this point and have your instructor check and initial your procedure and safe practice

INSTRUCTOR CHECK: Procedure ☐ Safety ☐ Initials ☐

**JOB SHEET #11--PARTS LIST FOR FORWARD CLUTCH AND
TURBINE SHAFT ASSEMBLY**

- 1 - Sealring
- 2 - Forward clutch and turbine shaft
assembly
- 3 - Sealring (2)
- 4 - Turbine shaft and clutch housing
assembly
- 5 - Check ball (2)
- 6 - Valve plug
- 7 - Valve spring
- 8 - Centrifugal valve
- 9 - Retainer pin
- 10 - Snapring
- 11 - PTO drive gear
- 12 - Housing sealring
- 13 - Piston sealring
- 14 - Forward clutch piston (ar):
 - 0.995—1.005 thk (A)
 - 1.020—1.030 thk (B)
 - 1.045—1.055 thk (C)
- 15 - Forward clutch piston spring
- 16 - Spring retainer
- 17 - Snapring
- 18 - Bearing race
- 19 - Roller bearing assembly
- 20 - Bearing race
- 21 - Forward clutch hub
- 22 - External-tanged plate (5)
- 23 - Internal-splined plate (5)
- 24 - Fourth-clutch driving hub
- 25 - Snapring
- 26 - Bearing race
- 27 - Roller bearing assembly
- 28 - Bearing race

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JOB SHEET #11--EXPLODED VIEW OF FORWARD CLUTCH AND
TURBINE SHAFT ASSEMBLY

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AUTOMATIC TRANSMISSIONS
UNIT V

JOB SHEET #12-DISASSEMBLE, CLEAN, INSPECT,
AND REASSEMBLE A FOURTH CLUTCH

I. Tools and materials

- A. Basic shop tools
- B. Clean shop towels
- C. Cleaning solvent in a clean container
- D. Compressed air supply for drying parts
- E. Compressor and compressor base
- F. Fourth clutch clearance gauge
- G. Oil-soluble grease
- H. Appropriate service manual
- I. Safety glasses

II. Procedure

(NOTE: The following procedure and illustrations are adapted from materials published by Detroit Diesel Allison, © General Motors Corporation, and are reprinted with permission; this procedure may be modified by your instructor to facilitate available equipment.)

A. Disassemble the fourth clutch with the following procedure:

1. Remove bearing race 28 from the front hub of fourth clutch housing 12 if it has not been previously removed

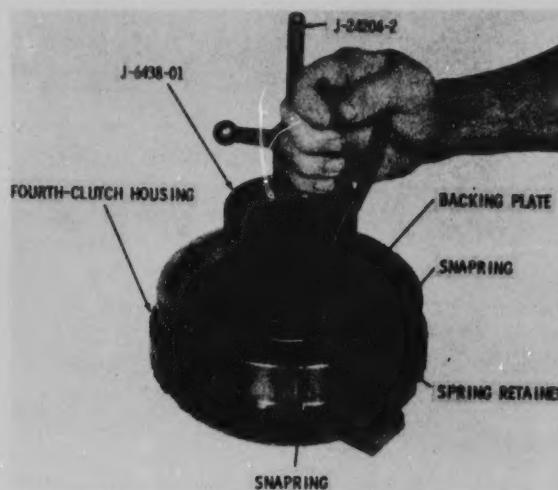
(NOTE: Refer to the parts list and exploded view that accompany this job sheet for parts identification.)

2. Remove bearing race 15 from the rear hub of the clutch housing

JOB SHEET #12

3. Using compressor J-6438-01 and compressor base J-24204-2, depress the spring retainer sufficiently to allow removal of the snapring (Figure 1)

FIGURE 1



4. Remove the snapring
5. Remove the spring retainer, and remove the clutch return spring which is directly beneath the retainer
6. Remove the snapring that retains the backing plate, and remove the back plate
7. Remove the eight clutch plates 4 and 5, and piston 9
8. Remove sealring 10 from the piston, and sealring 11 from fourth clutch housing 12
9. Remove balls 13 from fourth clutch housing 14 only if replacement is necessary; if necessary, clear the affected bores of staked metal and remove the balls
10. Clean and dry parts for inspection and reassembly
11. Inspect snaprings, springs, bearing races, and sealrings for damage or excessive wear; replace as needed

JOB SHEET #12

- B. Stop at this point and have your instructor check and initial your procedure and safe practice

INSTRUCTOR CHECK: Procedure ☐ Safety ☐ Initials ☐

- C. Reassemble the fourth clutch with the following procedure:

1. Replace balls 13 if they were removed
2. Place each ball in its bore
3. Stake each bore at three equally spaced places

(NOTE: Each bore is properly staked when the ball has at least 0.020 inch axial movement and when the ball is retained by the stakes when a 30 lb load is applied against the ball.)

4. Establish clutch clearance before completing the assembly by using the direct measurement method or stack dimension computation

(NOTE: The method for direct measurement is given in this procedure; stack dimension computation for clutch clearance is covered in the service manual.)

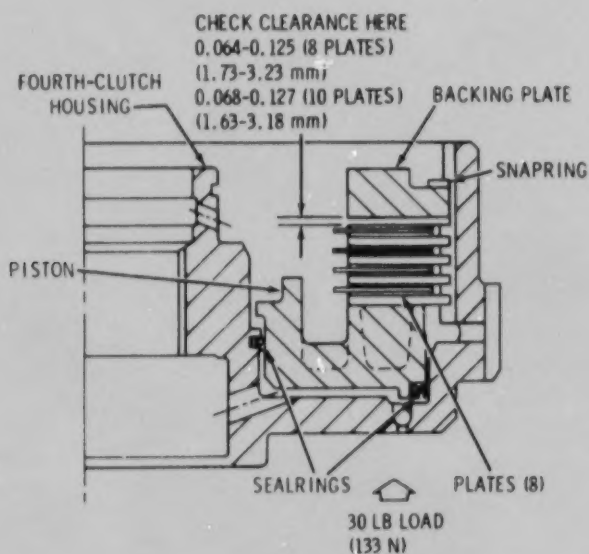
5. Position the fourth clutch housing, rear hub downward, on a work table
6. Lubricate and install the piston sealrings into their grooves in the housing hub and piston

JOB SHEET #12

7. Make sure the sealing lips face toward the oil pressure side of the piston (Figure 2)

(CAUTION: If either sealing is installed incorrectly, the fourth clutch will not operate properly.)

FIGURE 2



8. Install the piston into the fourth clutch housing (Figure 2)
9. Alternately install the four external-tanged plates and four internal-splined plates
10. Install the backing plate and retain it with the snapring
11. Using fourth clutch clearance gauge J-26917, check the clearance between the backing plate and the first internal-splined plate

(NOTE: The prescribed clearance for the fourth clutch is 0.064-0.125 inch; when this clearance is achieved, the first step of the gauge will fit between the backing plate and the clutch plate, but the second step of the gauge will not fit.)
12. When the second step of the gauge fits, clearance is excessive and the thinner clutch plates should be replaced with new ones
13. If the clearance is still excessive after all eight plates and the backing plate have been replaced, a thicker piston is required

JOB SHEET #12

14. When the first stage of the gauge will not fit, clearance is insufficient and a thinner piston is required

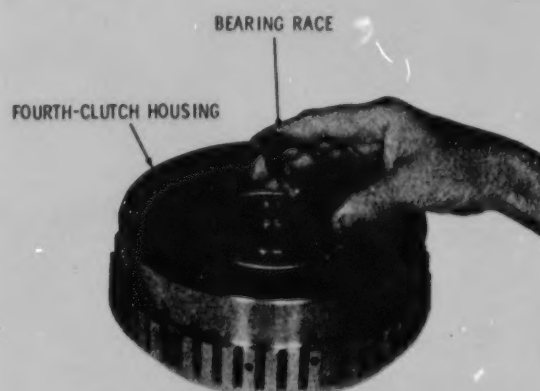
(NOTE: Refer to manufacturer's parts catalog for proper piston selection.)

15. Lubricate and install the piston sealings into their grooves in the housing hub and piston
16. Make sure the sealing lips face toward the oil pressure side of the piston (Figure 2)
17. Install the piston into the housing

(CAUTION: If either sealing is installed incorrectly, the fourth clutch will not operate properly.)

18. Install the piston return spring and spring retainer
19. Using compressor J-6438-01 and compressor base J-24204-2, depress the spring retainer (Figure 1)
20. Install the snapping to retain the spring retainer
21. Install the bearing race, outer lip first, onto the front hub of the clutch housing (Figure 3)

FIGURE 3

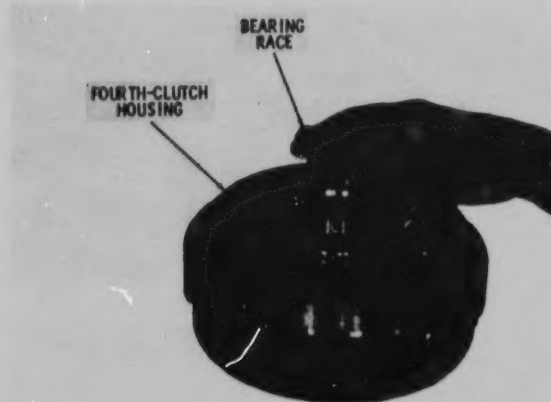


22. Use oil-soluble grease to retain the races during the rest of the assembly procedure

JOB SHEET #12

23. Install the bearing race, outer lip first, onto the rear hub of the clutch housing (Figure 4)

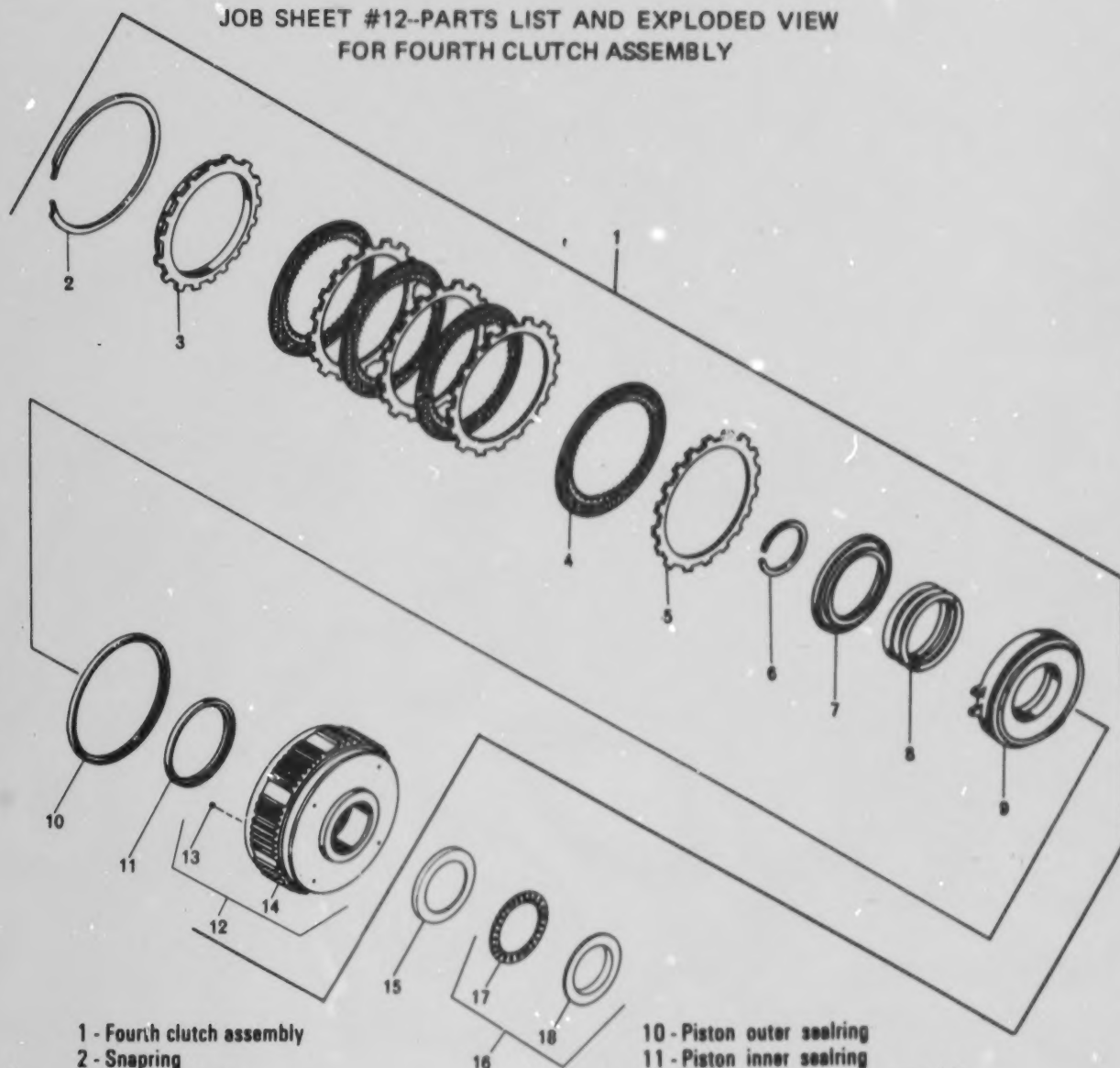
FIGURE 4



- D. Stop at this point and have your instructor check and initial your procedure and safe practice

INSTRUCTOR CHECK: Procedure ☐ Safety ☐ Initials ☐

JOB SHEET #12-PARTS LIST AND EXPLODED VIEW FOR FOURTH CLUTCH ASSEMBLY



- 1 - Fourth clutch assembly
- 2 - Snapping
- 3 - Clutch back plate
- 4 - Internal-splined plate (4)
- 5 - External-tanged plate (4)
- 6 - Snapping
- 7 - Piston spring retainer
- 8 - Piston return spring
- 9 - Fourth clutch piston (ar):
0.995—1.005 thk (A)
1.020—1.030 thk (B)

- 10 - Piston outer sealing
- 11 - Piston inner sealing
- 12 - Fourth clutch housing assembly
- 13 - Check ball (4)
- 14 - Fourth clutch housing
- 15 - Bearing race
- 16 - Roller bearing assembly
- 17 - Bearing
- 18 - Bearing race

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AUTOMATIC TRANSMISSIONS UNIT V

JOB SHEET #13-DISASSEMBLE, CLEAN, INSPECT, AND REASSEMBLE A CENTER SUPPORT ASSEMBLY

I. Tools and materials

- A. Basic shop tools
- B. Clean shop towels
- C. Cleaning solvent in a clean container
- D. Compressed air supply for drying parts
- E. Bushing installer
- F. Lockring installer
- G. Oil-soluble grease
- H. Appropriate service manual
- I. Safety glasses

II. Procedure

(NOTE: The following procedure and illustrations are adapted from materials published by Detroit Diesel Allison, © General Motors Corporation, and are reprinted with permission; this procedure may be modified by your instructor to facilitate available equipment.)

A. Disassemble the center support assembly with the following procedure:

1. Place center support assembly 14 vertically upright on a work table

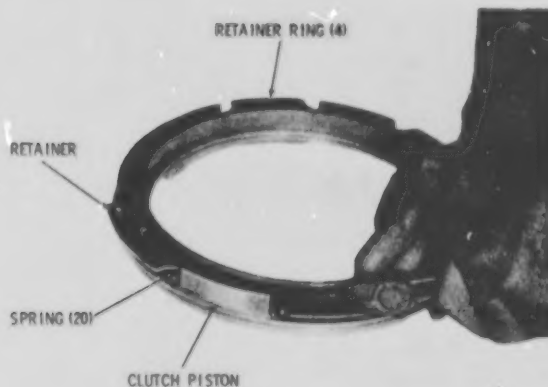
(NOTE: Refer to the parts list and exploded view that accompany this job sheet for parts identification.)

2. Remove pistons 10 and 20, with attached parts
3. Remove the inner and outer sealrings from each piston
4. If parts replacement is necessary, disassemble the two piston assemblies

JOB SHEET #13

5. Cut the self-locking retainer rings to prevent damaging the piston projections (Figure 1)

FIGURE 1

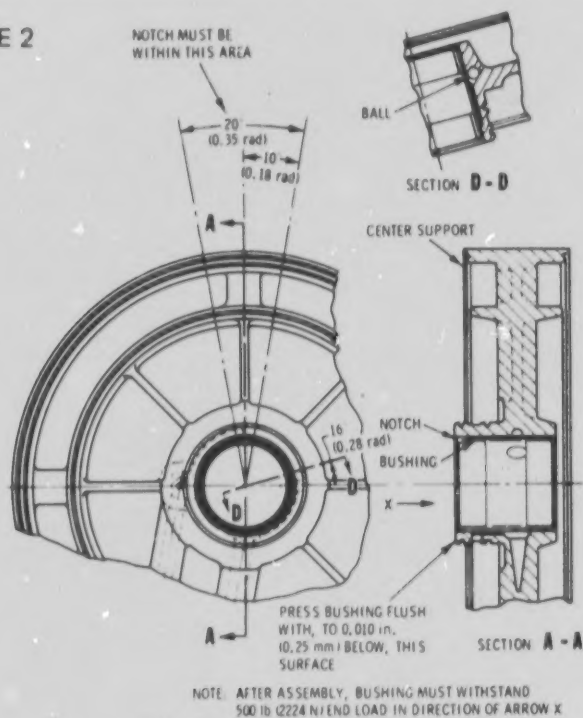


6. Remove four self-locking retainer rings, a retainer, and twenty springs from each piston
 7. Remove two step-joint sealrings 13 and bearing race 18 from the hub of the center support assembly
 8. If the bushing in the center bore of the support assembly is worn or damaged, mark the location of the notch in the bushing in relation to the center support
 9. Press the bushing from the support
 10. Remove the ball, freed by removing the bushing, from the hub of the support
 11. Clean and dry parts for inspection and reassembly
 12. Inspect bushing, retainer rings, retainer and springs for damage or excessive wear; replace as needed
- B. Stop at this point and have your instructor check and initial your procedure and safe practice
- INSTRUCTOR CHECK: Procedure Safety Initials
- C. Reassemble the center support assembly with the following procedure:
1. Install new parts if the bushing and balls were removed from the center support

JOB SHEET #13

2. Install the ball and bushing as illustrated in Figure 2

FIGURE 2

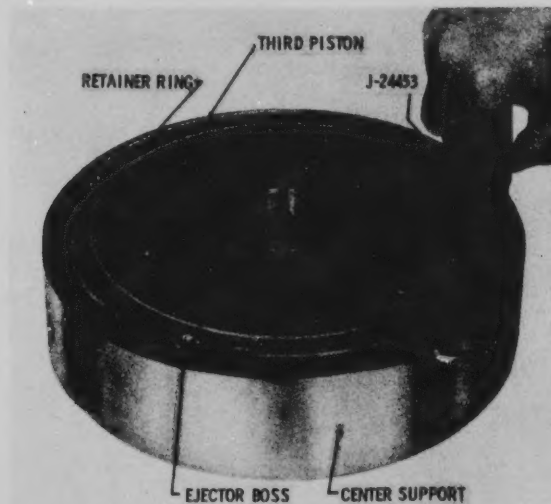


3. Use installer J-24794 to press the bushing into the center support
(NOTE: The bushing should be prebored and require no reaming.)
4. Engage the lug on the piston with the recess in the center support, and temporarily place piston 10 in front piston cavity of center support assembly 14
5. Install springs 9 into the pockets of the piston
6. Align spring retainer 8 on the four ejector pin bosses of the piston

JOB SHEET #13

7. Compress the springs by forcing the retainer into the recess at the outer edge of the center support when the self-locking retainer rings are installed (Figure 3)

FIGURE 3



8. Install new self-locking retainer rings on the ejector pins of the piston, using locking installer J-24453
9. Remove the piston from the center support
10. Repeat steps 4 through 9 to assemble items 20 through 23 into the rear cavity of center support assembly 14

(NOTE: If the pistons are not forced to the bottom of their cavities during installation of self-locking retainer rings 7 and 23, proper clutch clearance cannot be established.)

11. Use oil-soluble grease to grease, and then install inner sealrings 11 and 19, and outer sealrings 12 and 18 onto pistons 10 and 20

(NOTE: The lips of all the sealrings must be toward the piston cavities of the center support.)

12. Inspect the piston cavities in center support assembly 14 for any obstruction or foreign material

JOB SHEET #13

13. Install piston 20 into the rear of the center support, engaging the lug on the piston with the recess in the support

(NOTE: Be sure the lips of both the inner and outer sealrings face the bottom of the piston cavity.)

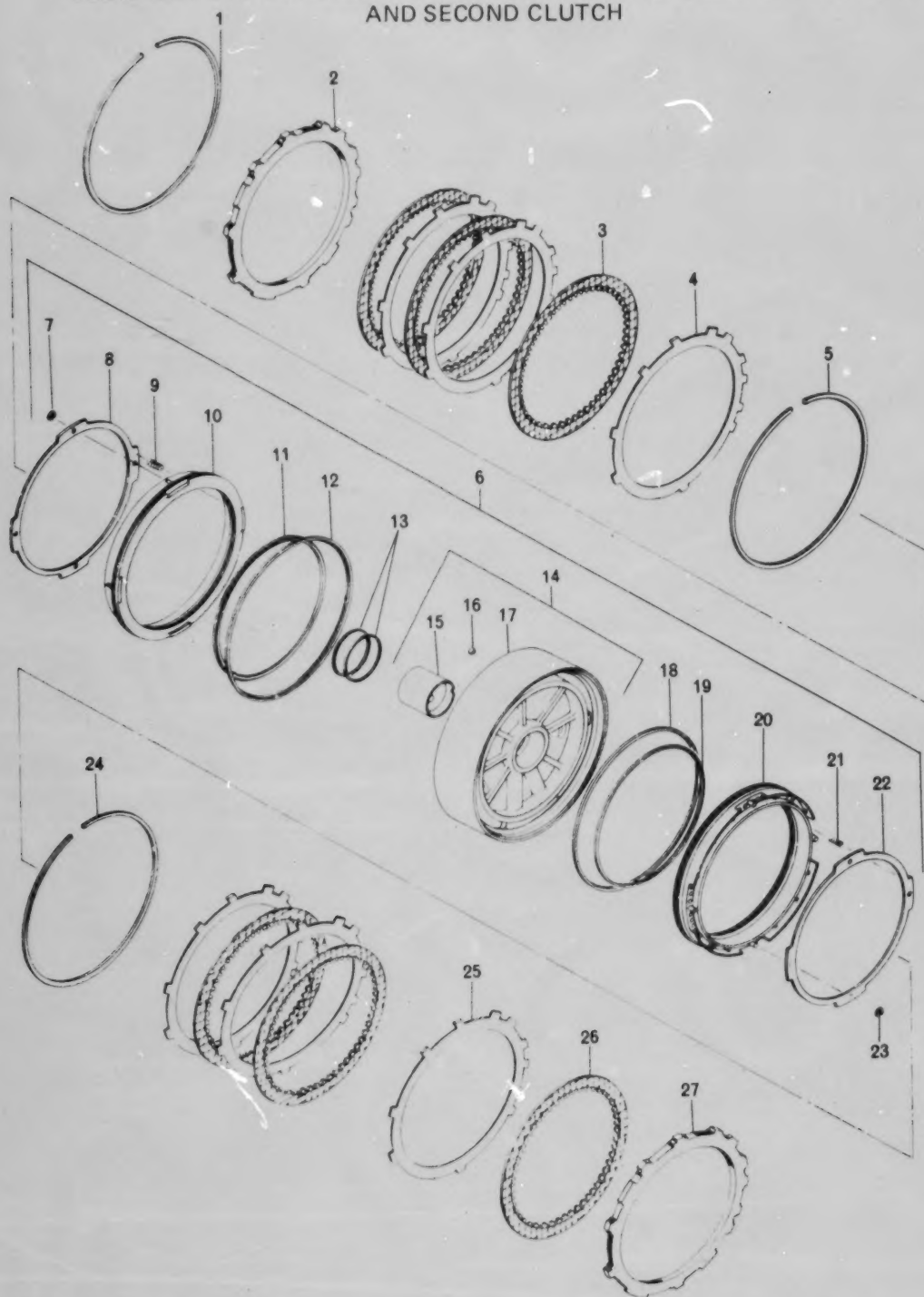
14. Leave the assembled third clutch piston out of the center support until final installation of the center support assembly
15. If oil filter and sealring were removed, install the new filter and sealring closed end of the cone first into the center support
16. Make sure the sealring on the filter seats against the shoulder in the support
- D. Stop at this point and have your instructor check and initial your procedure and safe practice

INSTRUCTOR CHECK: Procedure ☐ Safety ☐ Initials ☐

JOB SHEET #13--PARTS LIST FOR THIRD CLUTCH, CENTER SUPPORT,
AND SECOND CLUTCH

- | | |
|---------------------------------------|-------------------------------------|
| 1 - Snapring | 12 - Piston outer sealring |
| 2 - Third clutch back plate (ar): | 13 - Sealring (2) |
| 0.476—0.486 thk (No. 1) | 14 - Center support assembly |
| 0.450—0.460 thk (No. 2) | 15 - Bushing |
| 3 - Internal-splined clutch plate (3) | 16 - Check ball |
| 4 - External-tanged clutch plate (3) | 17 - Center support |
| 5 - Snapring (ar): | 18 - Piston outer sealring |
| 0.148—0.150 thk (blue) | 19 - Piston inner sealring |
| 0.152—0.154 thk (yellow) | 20 - Second clutch piston |
| 0.155—0.157 thk (green) | 21 - Piston return spring (20) |
| 0.158—0.160 thk (red) | 22 - Retainer ring |
| 6 - Center support assembly | 23 - Self-locking retainer ring (4) |
| 7 - Self-locking retainer ring (4) | 24 - Snapring |
| 8 - Retainer ring | 25 - External-tanged plate (3) |
| 9 - Piston return spring (20) | 26 - Internal-splined plate (3) |
| 10 - Third clutch piston | 27 - Second clutch back plate (ar): |
| 11 - Piston inner sealring | 0.476—0.486 thk (No. 1) |
| | 0.450—0.460 thk (No. 2) |

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JOB SHEET #13--EXPLODED VIEW OF THIRD CLUTCH, CENTER SUPPORT,
AND SECOND CLUTCH

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AUTOMATIC TRANSMISSIONS UNIT V

JOB SHEET #14-DISASSEMBLE, CLEAN, INSPECT, AND REASSEMBLE A GEAR UNIT AND MAIN SHAFT ASSEMBLY

- I. Tools and materials
 - A. Basic shop tools
 - B. Clean shop towels
 - C. Cleaning solvent in a clean container
 - D. Compressed air supply for drying parts
 - E. Bushing installer
 - F. Oil-soluble grease
 - G. Plug installer
 - H. Appropriate service manual
 - I. Safety glasses

- II. Procedure

(NOTE: The following procedure and illustrations are adapted from materials published by Detroit Diesel Allison, © General Motors Corporation, and are reprinted with permission; this procedure may be modified by your instructor to facilitate available equipment.)

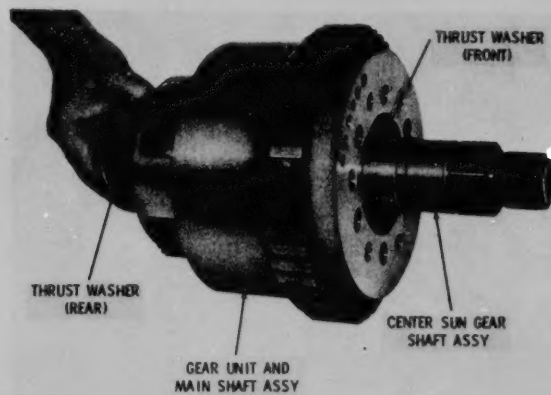
- A. Disassemble the gear unit and main shaft assembly with the following procedure:
 - 1. Refer to the parts list and exploded view that accompany this job sheet for proper parts identification

(NOTE: This disassembly and reassembly procedure is for Allison models MT 650 and 654; depending on available equipment, your instructor may refer you to the Allison service manual for procedures covering models MT 640 and 643 for this same activity.)

JOB SHEET #14

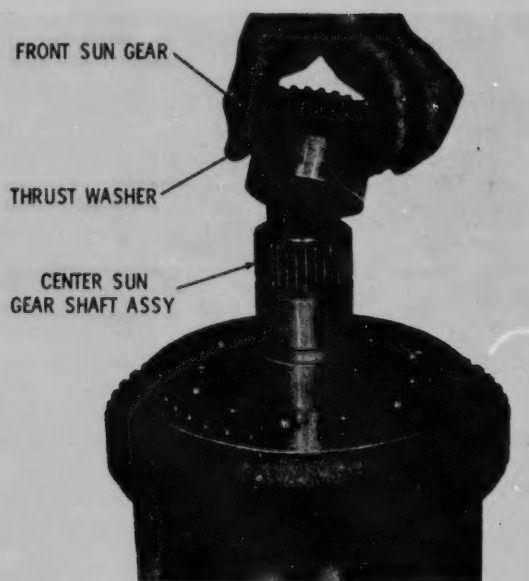
2. Remove the thrust washers that are at each end of the gear unit assembly (Figure 1)

FIGURE 1



3. Remove the front sun gear (Figure 2)

FIGURE 2



4. Remove the thrust washer from the gear or center sun gear shaft assembly

JOB SHEET #14

5. Lift off the front planetary carrier assembly and remove the thrust washer from the assembly (Figure 3)

FIGURE 3



6. Remove the center sun gear shaft assembly (Figure 4)

FIGURE 4



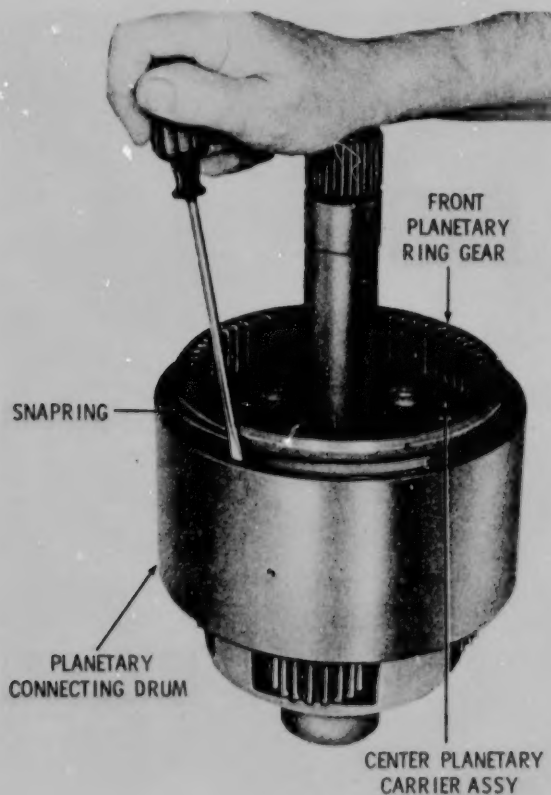
JOB SHEET #14

7. If parts replacement is necessary, remove bushing 26 and spring pins 24 from shaft assembly 23

(NOTE: Bearing assembly 28 and bearing race 29 may come out when sun gear shaft assembly 23 is removed.)

8. Remove bearing assembly 28 and bearing race 29 if not removed in step 7
9. Remove the snapping that retains the front planetary gear (Figure 5)

FIGURE 5

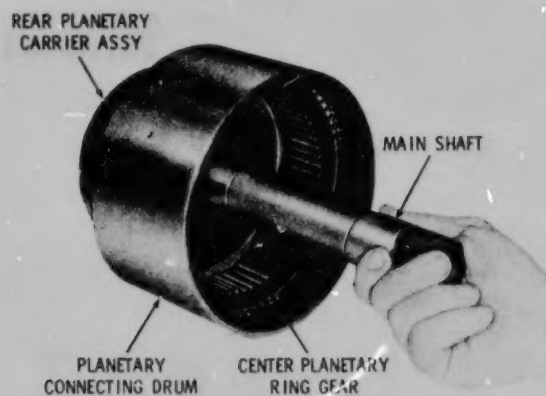


10. Remove the ring gear from the planetary connecting drum
11. Lift out the center planetary carrier assembly (Figure 5)

JOB SHEET #14

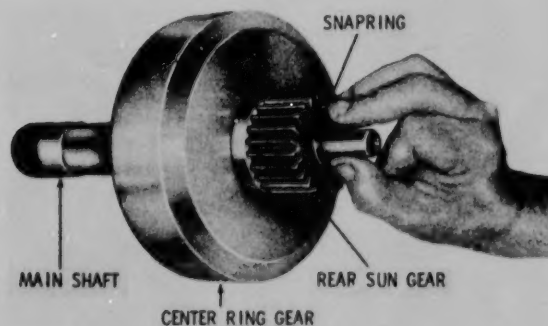
12. Remove the main shaft, and its attached parts from the planetary connecting drum (Figure 6)

FIGURE 6



13. Remove the spiral snapping that retains the rear planetary sun gear on the main shaft (Figure 7)

FIGURE 7



14. Remove the main shaft
15. Remove orifice 34 from shaft 35 only if replacement is necessary
16. Remove snapping 31
17. Remove rear planetary sun gear 36 from center planetary ring gear 32

JOB SHEET #14

18. Remove the snapping that retains the rear planetary carrier assembly in the planetary connecting drum (Figure 8)

FIGURE 8



19. Lift the carrier assembly out of the drum
 20. Remove needle bearing assembly 39

(NOTE: Needle bearing assembly 39 may not easily come out of the rear planetary carrier assembly; in most cases, it can be removed by careful manipulation after rotating the planetary pinions to allow the bearing race to tilt; if the bearing assembly cannot be removed at this point, refer to the special planetary carrier assembly section of the service manual.)

21. Clean and dry parts for inspection and reassembly
 22. Inspect all parts for damage or excessive wear
 B. Stop at this point and have your instructor check and initial your procedure and safe practice

INSTRUCTOR CHECK: Procedure ☐ Safety ☐ Initials ☐

- C. Reassemble the gear unit and main shaft assembly with the following procedure:
 1. If lubrication orifice plug 34 was removed from shaft 35, install a new plug, using installer J-24369

JOB SHEET #14

2. Install the plug, small-orificed end first, into the front of the main shaft
3. Press the plug into the shaft until the front of the plug is recessed 0.140 to 0.180 inch below the front end of the shaft
4. If spring pins 24 were removed from shaft assembly 23, install new pins
5. Press each pin into the shaft, split in pin must be directly toward either adjacent spline tooth, until the outer end of the pin is flush with, to 0.010 inch below, the top of the adjacent spline teeth
6. If bushings 26 were removed from shaft assembly 23, install new bushings, using installer J-24468 (Figure 9)

(NOTE: The installer is designed to position each bushing at a different depth.)

7. Position front bushing at 0.400 to 0.420 inch depth
8. Position rear bushing at 0.650 to 0.670 inch depth

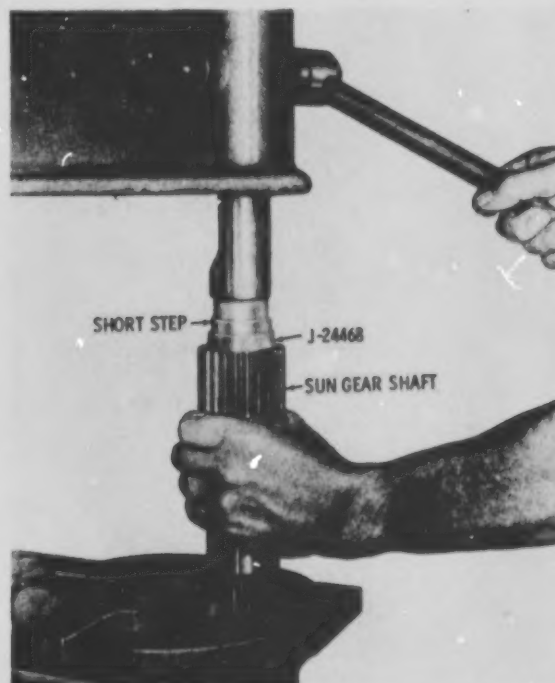
JOB SHEET #14

9. Install front bushing and rear bushing as shown in Figures 9 and 10

FIGURE 9



FIGURE 10

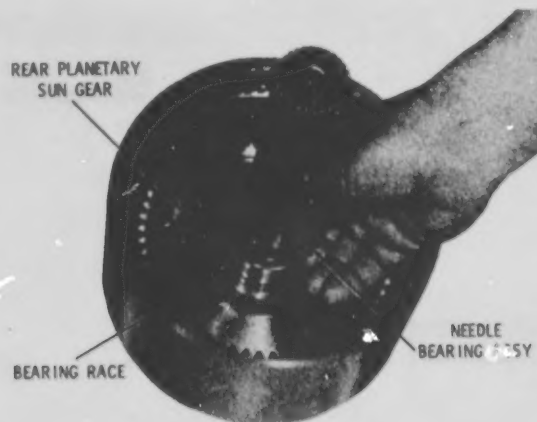


10. Check to insure that the bore of each bushing, installed, is concentric with the finished outside diameter of shaft 23 within 0.002 inch
11. Position the planetary connecting drum with front, long internal splines, downward (Figure 8)
12. Install the rear planetary carrier assembly
13. Install the snapping that retains the carrier assembly in the drum
14. Install rear planetary sun gear 36 into the rear of center planetary ring gear 32
15. Retain the sun gear with snapping 31
16. Install the main shaft into the front of the rear planetary sun gear (Figure 7)

JOB SHEET #14

17. Retain the main shaft in the sun gear by installing the spiral snapping into the groove in the main shaft
18. Install the main shaft, and its attached parts, into the planetary connecting drum (Figure 6)
19. Make sure the sun gear is seated against the thrust bearing in the rear planetary carrier
20. Position the components assembled thus far so the hub of the rear planetary carrier assembly is downward (Figure 11)

FIGURE 11



21. Install the needle bearing race, inner lip upward, onto the front of the rear planetary sun gear
22. Retain the race with oil-soluble grease
23. Install the needle bearing assembly, coated with oil-soluble grease, onto the bearing race
24. Install the center planetary carrier assembly, pinions first, into the center planetary ring gear and planetary connecting drum (Figure 5)
25. Install the front planetary ring gear, outer splines first
26. Retain the ring gear with a snapping
27. Install the center sun gear shaft assembly, larger diameter first (Figure 4)
28. Make sure the shaft is seated on the needle bearing assembly installed in steps 21 through 23 preceding

JOB SHEET #14

29. Coat the thrust washer with oil-soluble grease and install it onto the rear hub of the front planetary carrier assembly (Figure 3)
 30. Install the carrier assembly
 31. Coat the thrust washer with oil-soluble grease and install it onto the rear hub of the front planetary sun gear (Figure 2)
 32. Install the sun gear onto the center sun gear shaft assembly so that the missing internal spline locations of the sun gear index with the spring pins in the center sun gear shaft assembly
 33. Coat both the front and rear thrust washers with oil-soluble grease, and install them onto the assembled gear unit (Figure 1)
- D. Stop at this point and have your instructor check and initial your procedure and safe practice

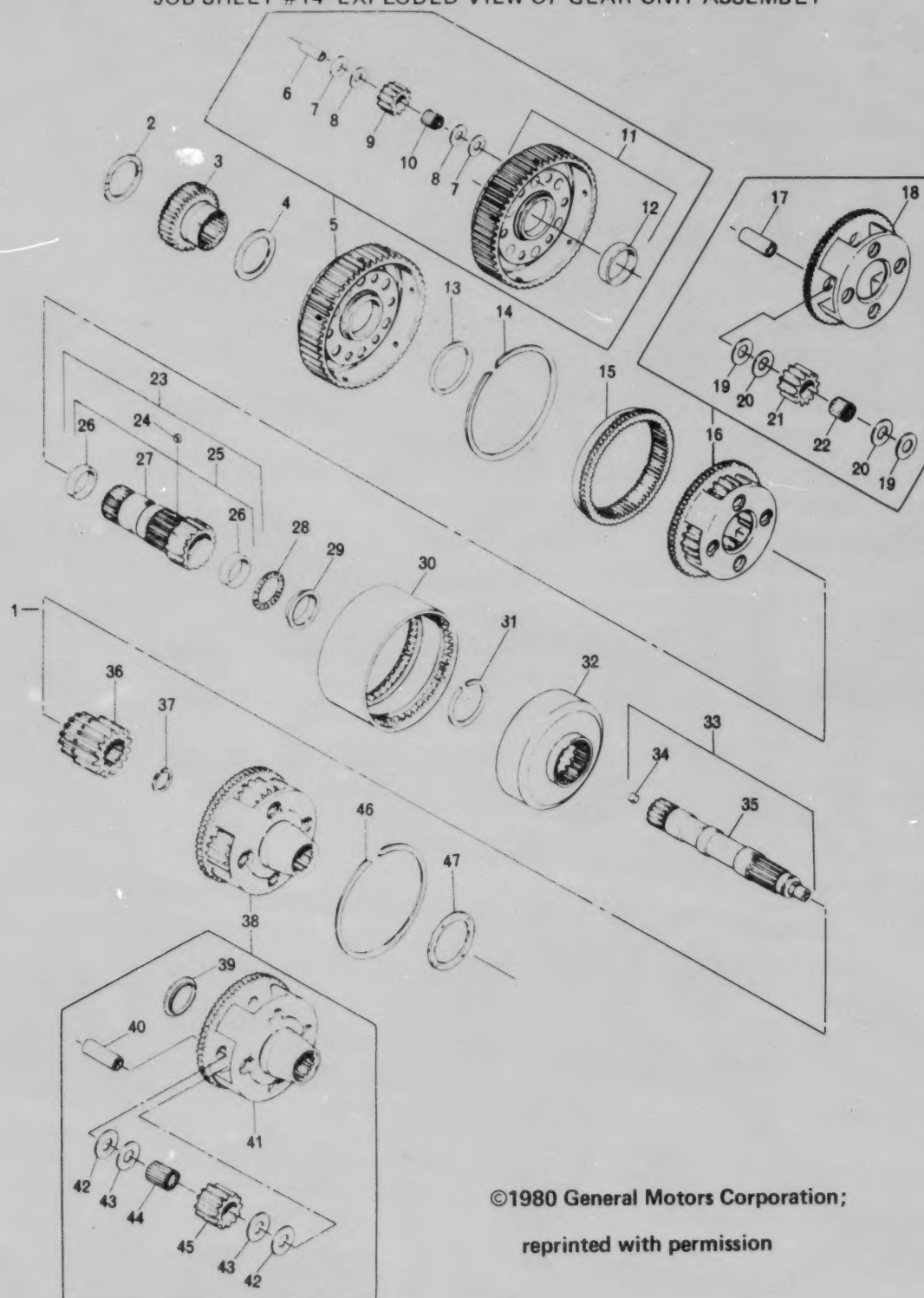
INSTRUCTOR CHECK: Procedure ☐ Safety ☐ Initials ☐

JOB SHEET #14-PARTS LIST FOR GEAR UNIT ASSEMBLY

- | | |
|---|--------------------------------------|
| 1 - Gear unit and shaft assembly
(MT 650, 653) | 24 - Spring pin (2) |
| 2 - Thrust washer | 25 - Shaft and bushing assembly |
| 3 - Front sun gear | 26 - Sleeve bushing (2) |
| 4 - Thrust washer | 27 - Sun gear shaft |
| 5 - Front planetary carrier assembly | 28 - Needle roller bearing assembly |
| 6 - Pinion pin (6) | 29 - Bearing race |
| 7 - Bronze thrust washer (12) | 30 - Planetary connecting drum |
| 8 - Steel thrust washer (12) | 31 - Snapring |
| 9 - Pinion (6) | 32 - Center planetary ring gear |
| 10 - Roller (120) | 33 - Main shaft assembly |
| 11 - Front planetary carrier assembly | 34 - Lubrication orifice plug |
| 12 - Bushing | 35 - Main shaft |
| 13 - Thrust washer | 36 - Rear planetary sun gear |
| 14 - Snapring | 37 - Snapring |
| 15 - Front planetary ring gear | 38 - Rear planetary carrier assembly |
| 16 - Center planetary carrier assembly | 39 - Needle bearing assembly |
| 17 - Pinion pin (4) | 40 - Pinion pin (4) |
| 18 - Center planetary carrier | 41 - Rear planetary carrier |
| 19 - Bronze thrust washer (8) | 42 - Bronze thrust washer (8) |
| 20 - Steel thrust washer (8) | 43 - Steel thrust washer (8) |
| 21 - Center planetary pinion (4) | 44 - Roller (72) |
| 22 - Roller (72) | 45 - Pinion (4) |
| 23 - Center sun gear shaft assembly | 46 - Snapring |
| | 47 - Thrust washer |

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JOB SHEET #14--EXPLODED VIEW OF GEAR UNIT ASSEMBLY



AUTOMATIC TRANSMISSIONS UNIT V

JOB SHEET #15-DISASSEMBLE, CLEAN, INSPECT, AND REASSEMBLE AN OUTPUT SHAFT

- I. Tools and materials
 - A. Basic shop tools
 - B. Clean shop towels
 - C. Cleaning solvent in a clean container
 - D. Compressed air supply for drying parts
 - E. Bearing and gear remover with drive handle
 - F. Rear bearing installer and drive handle
 - G. Press
 - H. Appropriate service manual
 - I. Safety glasses

- II. Procedure

(NOTE: The following procedure and illustrations are adapted from materials published by Detroit Diesel Allison, © General Motors Corporation, and are reprinted with permission; this procedure may be modified by your instructor to facilitate available equipment.)

- A. Disassemble the output shaft with the following procedure:
 - 1. Place the output shaft assembly on a press, small end of shaft downward
 - 2. Install remover J-22912-01 so the flat side of the puller plates make contact with the forward edge of the governor gear teeth
 - 3. Force the shaft down with the press until spring 5 clears the slot and is free in the "v" portion of gear 7

(NOTE: Refer to the parts list and exploded view that accompany this job sheet for parts identification; this procedure is for assemblies requiring governor drive gear press-fit installation; assemblies without governor press-fit requirements will be treated later in this job sheet.)

- 4. Remove spring pin 5, governor drive gear 8, and ball bearing 6 (or roller bearing 7) from output shaft 4
 - 5. If the bearing resists movement, use remover J-22912-01 to complete disassembly

JOB SHEET #15

6. Remove needle roller bearing 1 and cup plug 3 only if parts replacement is necessary

(NOTE: On output shaft assemblies not having a press-fit governor drive gear, remove spring pin 5 from output shaft 4, and press ball bearing 6 [or roller bearing 7] from the shaft, using remover J-22912-01.)

7. Clean and dry parts for inspection and reassembly

8. Inspect all parts for damage or excessive wear

- B. Stop at this point and have your instructor check and initial your procedure and safe practice

INSTRUCTOR CHECK: Procedure ☐ Safety ☐ Initials ☐

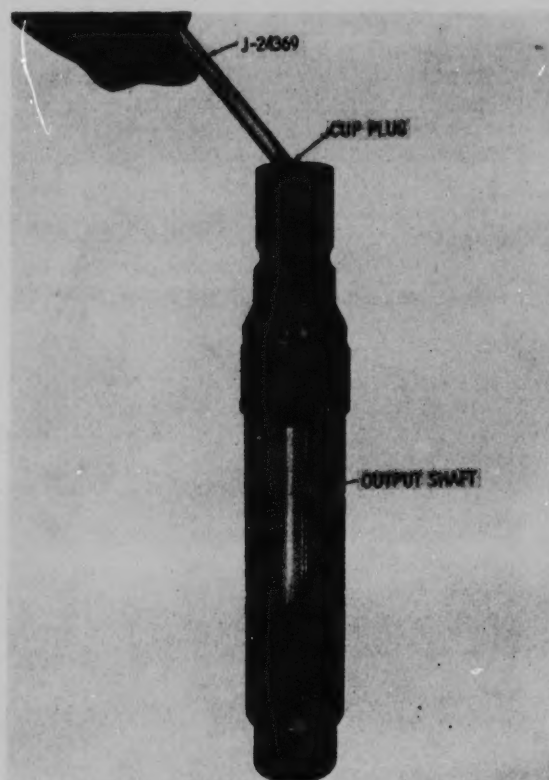
- C. Reassemble the output shaft with the following procedure:

1. If cup plug 3 was removed from shaft 4, install a new plug
2. Place the plug on the end of installer J-24369
3. Install the plug into the output shaft as shown in Figure 1
4. If bearing 1 was removed from shaft 4, install a new bearing

JOB SHEET #15

5. Place bearing 1 on installer with numbered end of bearing facing tool (Figure 1)

FIGURE 1

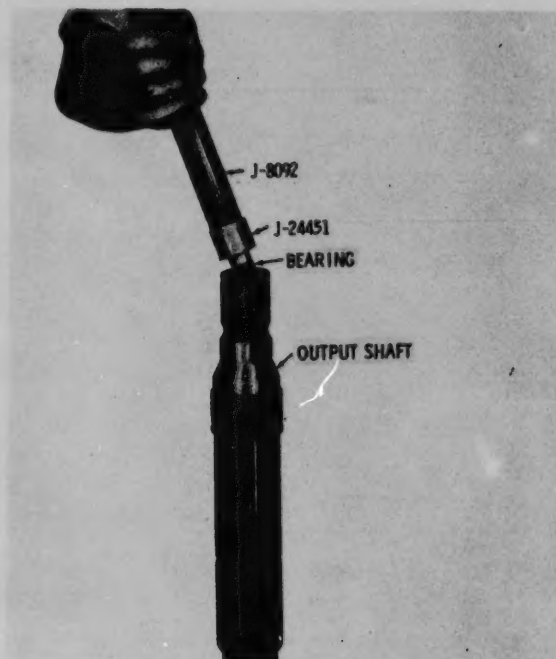


JOB SHEET #15

6. Attach driver handle J-8092 to the installer and install the bearing into the output shaft as shown in Figure 2

(NOTE: If the installer is not available, insert the bearing onto the output shaft; press on the numbered end of the bearing, locating bearing 0.270 to 0.290 inch below the front surface of the shaft.)

FIGURE 2



7. Replace ball bearing 6 with roller bearing 7, when replacement is required
8. Place output shaft 4 on a press, small end downward
9. Place roller bearing 7, chamfered end first, onto shaft 4
10. Place a steel sleeve, 2.375 inside diameter x 2.875 outside diameter x 1.750 long, next to the bearing
11. Install tools J-24447 and J-24202-4 onto the output shaft and press roller bearing 7 against the shoulder on the shaft
12. Remove the tools and the sleeve from the output shaft
13. Press spring pin 5 into its hole in shaft 4 until it protrudes 0.150 to 0.170 inch above the surface

JOB SHEET #15

14. Place governor drive gear 8, slot first, onto shaft 4
 15. Precisely align the slot in the gear with spring pin 5 on the shaft
 16. Place installer J-24447 and driver handle J-24202-4, in that sequence, onto shaft 4 and press governor drive gear 8 into place
- D. Stop at this point and have your instructor check and initial your procedure and safe practice

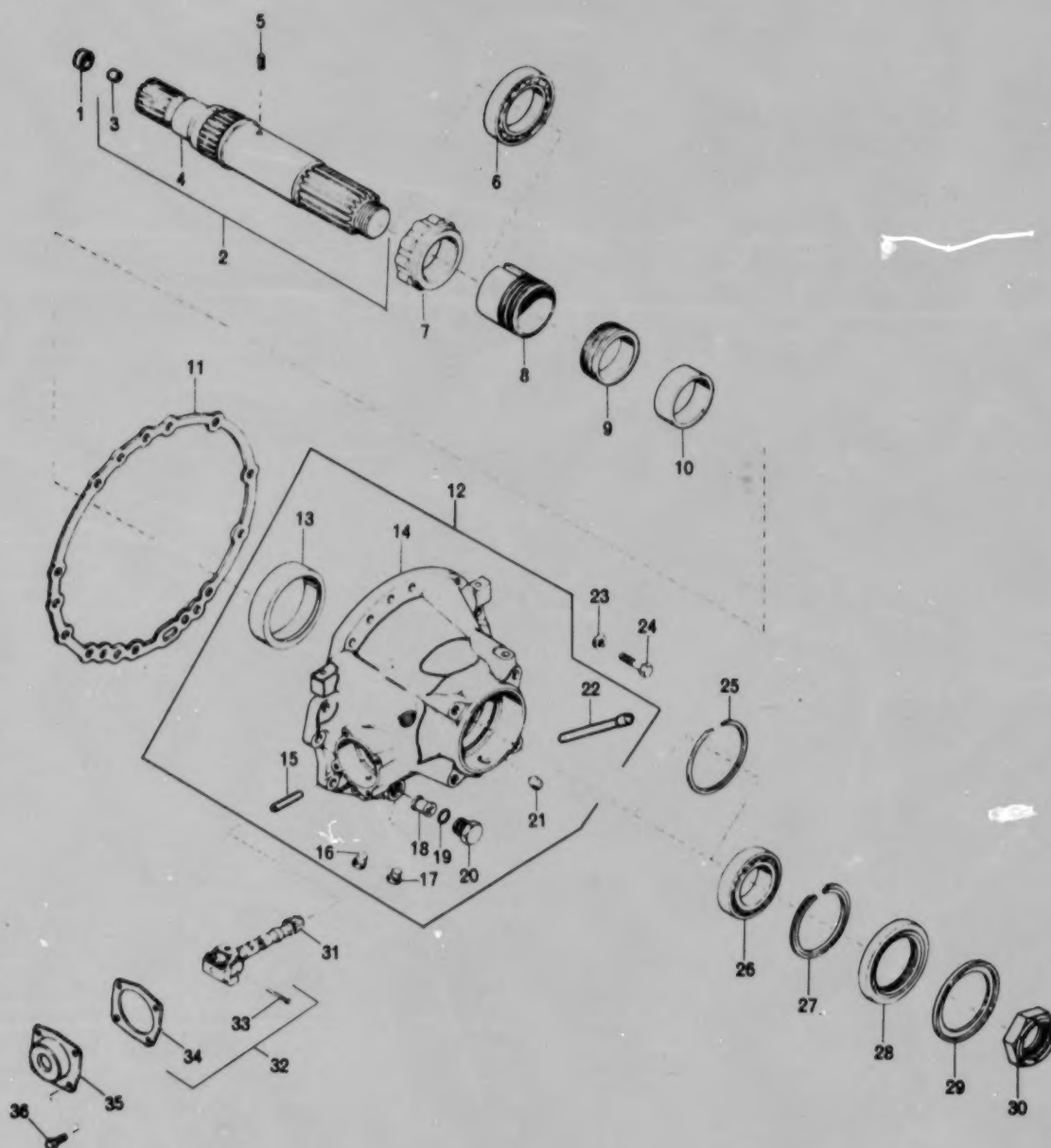
INSTRUCTOR CHECK: Procedure ☐ Safety ☐ Initials ☐

JOB SHEET #15--PARTS LIST FOR OUTPUT SHAFT
AND REAR COVER ASSEMBLY

- | | |
|---|--------------------------------|
| 1 - Needle bearing assembly | 19 - Sealing |
| 2 - Shaft and plug assembly | 20 - Filter plug |
| 3 - Cup plug | 21 - Plug, 3/8 |
| 4 - Output shaft | 22 - Drain tube |
| 5 - Spring pin | 23 - Flat washer, 1/2 (14) |
| 6 - Ball bearing assembly (early models) | 24 - Bolt, 1/2-13 x 5-1/4 (14) |
| 7 - Roller bearing (late models) | 25 - Snapping (early models) |
| 8 - Governor drive gear | 26 - Ball bearing |
| 9 - Speedometer drive gear | 27 - Snapping |
| 10 - Sleeve spacer | 28 - Oil seal |
| 11 - Rear cover gasket | 29 - Dust shield |
| 12 - Rear cover assembly | 30 - Self-locking nut |
| 13 - Roller bearing outer race (later models) | 31 - Governor assembly |
| 14 - Rear cover | 32 - Governor service kit |
| 15 - Governor support pin | 33 - Governor weight pin (2) |
| 16 - Plug, 1/8 | 34 - Gasket |
| 17 - Plug, 1/8 | 35 - Governor cover |
| 18 - Governor oil filter | 36 - Bolt, 5/16-18 x 9/16 (4) |

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JOB SHEET #15-EXPLODED VIEW OF OUTPUT SHAFT
AND REAR COVER ASSEMBLY



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AUTOMATIC TRANSMISSIONS UNIT V

JOB SHEET #16--DISASSEMBLE, CLEAN, INSPECT, AND REASSEMBLE A REAR COVER ASSEMBLY

I. Tools and materials

- A. Basic shop tools
- B. Clean shop towels
- C. Cleaning solvent in a clean container
- D. Compressed air supply for drying parts
- E. Output shaft oil seal and dust shield remover assembly
- F. Spring compressor and compressor base
- G. Clean transmission fluid
- H. Rear bearing installer
- I. Rear seal installer
- J. Nonhardening sealer
- K. Dust shield installer
- L. Appropriate service manual
- M. Safety glasses

II. Procedure

(NOTE: The following procedure and illustrations are adapted from materials published by Detroit Diesel Allison, © General Motors Corporation, and are reprinted with permission; this procedure may be modified by your instructor to facilitate available equipment.)

A. Disassemble the rear cover assembly with the following procedure:

1. Place rear cover assembly 12 on a work table, front side down

(NOTE: Refer to the parts list and exploded view that accompany Job Sheet #15 for parts identification.)

JOB SHEET #16

2. Using remover J-24171, remove the dust shield as shown in Figure 1
3. Using remover J-24171, remove the oil seal from the rear cover as shown in Figure 2

FIGURE 1



FIGURE 2

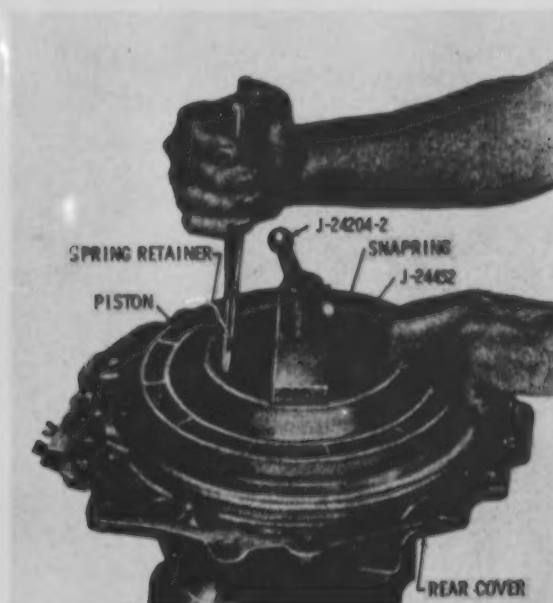


4. After removing the beveled snapping that retains the rear output shaft bearing, remove the bearing; use a soft drift and drive against the bearing outer race
5. Place spring compressor J-24452 on the piston ring retainer
6. Install spring compressor base J-24204-2

JOB SHEET #16

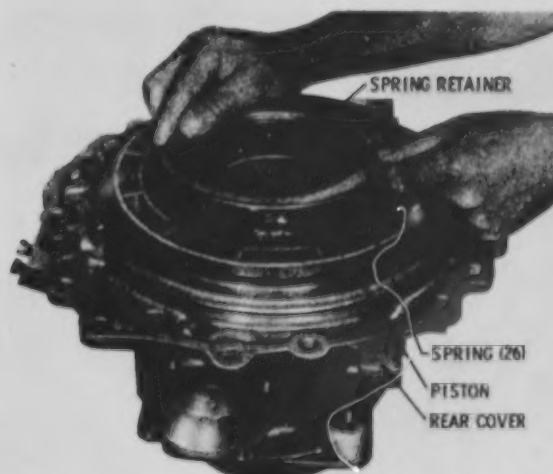
7. Compress the spring retainer and remove the snapping (Figure 3)

FIGURE 3



8. Release the spring compressor carefully and remove it
9. Remove the spring retainer and twenty-six springs (Figure 4)

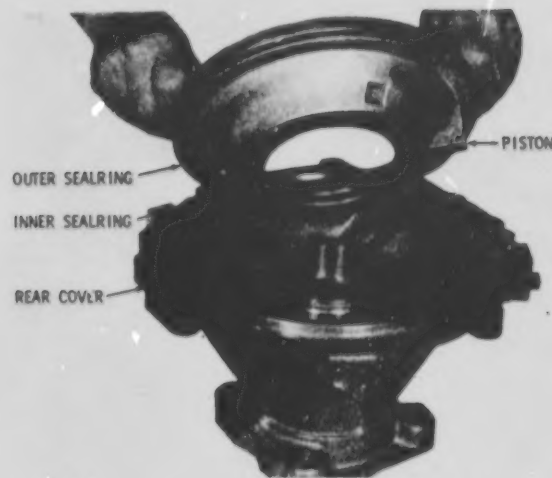
FIGURE 4



JOB SHEET #16

10. Remove the clutch piston (Figure 5)

FIGURE 5



11. Remove the inner and outer sealrings from the piston
12. Remove plugs 16, 17, and 20, sealring 19, and governor oil filter 18 from cover 14

(NOTE: Earlier Allison models use a conical metal oil filter screen, retained in the housing by plug 17; do not use the conical screen when filter 18 is used.)

13. Remove roller bearing outer race 13 only if replacement is necessary
14. Remove all remaining parts, tube, snapping, governor support pin, and plugs, that require replacement, from the rear cover
15. Clean and dry parts for inspection and reassembly
16. Inspect all parts for damage or excessive wear

- B. Stop at this point and have your instructor check and initial your procedure and safe practice

INSTRUCTOR CHECK: Procedure ☐ Safety ☐ Initials ☐

- C. Reassemble the rear cover assembly with the following procedure:

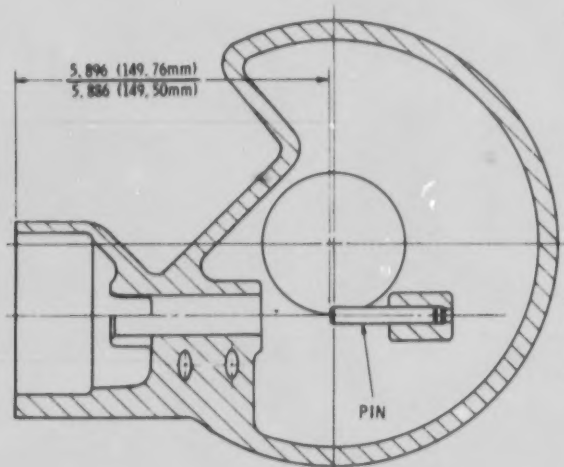
1. On earlier model rear covers, install the front snapping 25

JOB SHEET #16

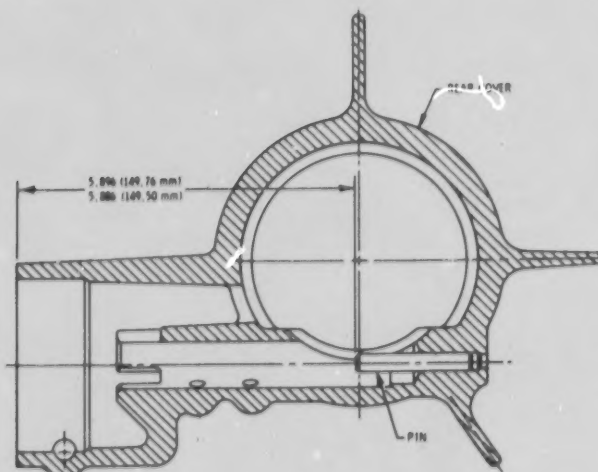
2. Install plugs 16, 17, and 21
3. If removed, install the governor support pin to the dimensions shown in Figure 6

(NOTE: Accuracy of location and concentricity with the governor bore is of the utmost importance when installing the governor support pin.)

FIGURE 6



Governor pin, late models



Governor pin, early models

JOB SHEET #16

4. Install drain tube into rear cover 14 by pressing the tube until it is 0.050 to 0.100 inch from the chamfer in the cover (Figure 7)

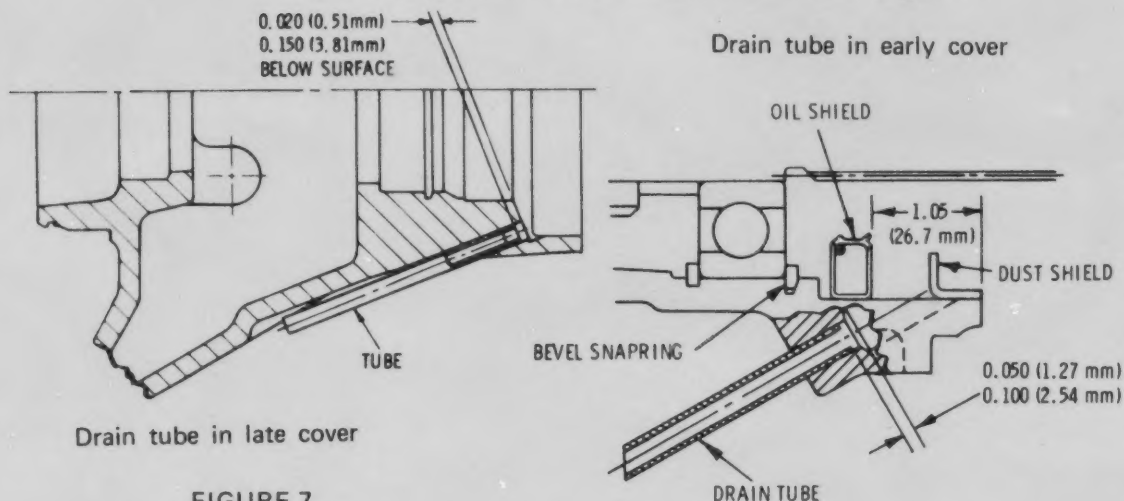


FIGURE 7

5. Lubricate sealrings with transmission fluid, and install them into the grooves of piston (earlier models)

(NOTE: The lip of each sealring must face the rear of the piston, toward the piston cavity in rear cover.)

6. Install the piston carefully into the rear cover (Figure 5)

(CAUTION: Use extreme care to prevent the lip of either seal folding back over itself; if installation is difficult, remove the piston and check the seal and cover bore again before attempting installation.)

7. Install one spring into each of twenty-six pockets of the low piston
8. Install the spring retainer, cupped side first, onto the springs (Figure 4)
9. Install spring compressor base J-24204-2 and compressor J-24452
10. Compress the twenty-six springs until the snapping can be installed as shown in Figure 3
11. Place the ball bearing into the rear cover
12. Using rear bearing installer J-24447, install the bearing until it seats firmly in the rear cover

(NOTE: On earlier models, the bearing is seated against a snapping as shown in Figure 7.)

JOB SHEET #16

13. Install the bearing snapping, beveled side toward the rear of the transmission, and be sure the snapping is fully expanded into its groove
14. Apply a nonhardening sealer (Perfect Sealer No. 4 or equivalent) onto the outer circumference of the rear oil seal
15. Place the seal onto the rear seal installer J-24620, spring-loaded side away from the installer
16. Insert the seal installer and the oil seal into the rear cover and drive the seal into the bore until its rearward surface is 1.03 to 1.07 inch below the rear face of the rear cover assembly as shown in Figure 7

(NOTE: The installer will seat when seal is properly positioned.)

17. Place the dust shield onto dust shield installer J-24198, concave side first
18. Coat the outer circumference of the shield with a nonhardening sealer
19. Drive the shield into the rear cover, as shown in Figure 7, until it is flush with, to 0.040 inch below, the rear face of the rear cover assembly
20. Install filter 18 and sealring 19 into cover 14

(NOTE: On earlier models, install the conical metal screen before installing plug 17.)

21. If roller bearing outer race 13 was removed, or if ball bearing 6 is being replaced with roller bearing 7, install race 13 into the front of cover 14

(NOTE: The race must be installed, inner lip first, until the front end of the race is 0.080 to 0.090 inch below the surface adjacent to the bore into which the race is installed.)

- D. Stop at this point and have your instructor check and initial your procedure and safe practice

INSTRUCTOR CHECK: Procedure ☐ Safety ☐ Initials ☐

AUTOMATIC TRANSMISSIONS UNIT V

JOB SHEET #17--DISASSEMBLE, CLEAN, INSPECT, AND REASSEMBLE AN ADAPTER HOUSING AND FIRST CLUTCH PISTON

I. Tools and materials

- A. Basic shop tools
- B. Clean shop towels
- C. Cleaning solvent in a clean container
- D. Compressed air supply for drying parts
- E. Compressor, compressor base, and base screw
- F. Appropriate service manual
- G. Safety glasses

II. Procedure

(NOTE: The following procedure and illustrations are adapted from materials published by Detroit Diesel Allison, © General Motors Corporation, and are reprinted with permission; this procedure may be modified by your instructor to facilitate available equipment.)

- A. Disassemble the adapter housing and first clutch piston with the following procedure:

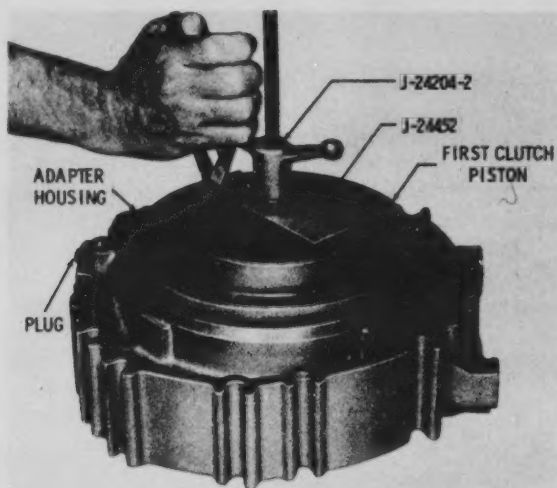
- 1. Place the adapter housing and attached piston, piston upward, on the work table

(NOTE: Refer to the parts lists and exploded views that accompany this job sheet for parts identification.)

JOB SHEET #17

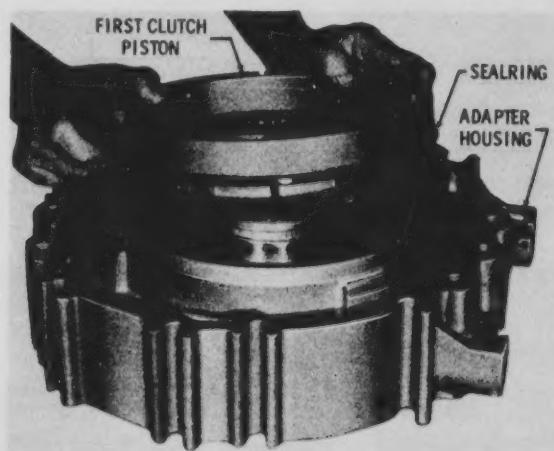
2. Install compressor J-24452 onto the first clutch spring retainer (Figure 1)

FIGURE 1



3. Attach compressor base J-24204-2, and tighten base screw, compressing retainer springs
4. Remove the snapping, retainer, and 26 piston return springs
5. Remove the first clutch piston from the adapter housing, and remove the seal rings from the piston (Figure 2)

FIGURE 2



JOB SHEET #17

6. Remove plug 4 (B-9) only if necessary for cleaning the internal passages in the housing
 7. Clean and dry parts for inspection and reassembly
 8. Inspect all parts for damage or excessive wear
- B. Stop at this point and have your instructor check and initial your procedure and safe practice
- INSTRUCTOR CHECK: Procedure ☐ Safety ☐ Initials ☐
- C. Reassemble the adapter housing and first clutch piston with the following procedure:
1. If the 1/4-18 plug 4 (B-9) was removed, replace it
 2. Tighten the plug sufficiently to prevent leakage (Figure 2)
 3. Lubricate and install the piston sealrings into their grooves in the piston (Figure 2)
 4. Make sure that the sealring lips face toward the oil pressure side, cavity in adapter housing, of the piston
 5. Align the lug on the piston with the recess in the housing and install the piston
 6. Install twenty-six piston return springs 10 (A-9) into the pockets of first clutch piston 11
 7. Place spring retainer 9, cupped side first, on top of the twenty-six springs
 8. Place compressor J-24452 onto the spring retainer (Figure 1)
 9. Install compressor base J-24204-2 as shown in Figure 1
 10. Tighten the compressor base center screw handle to allow sufficient clearance for installation of the spring retainer snapping
 11. Install the snapping and remove the compressor tool
- D. Stop at this point and have your instructor check and initial your procedure and safe practice

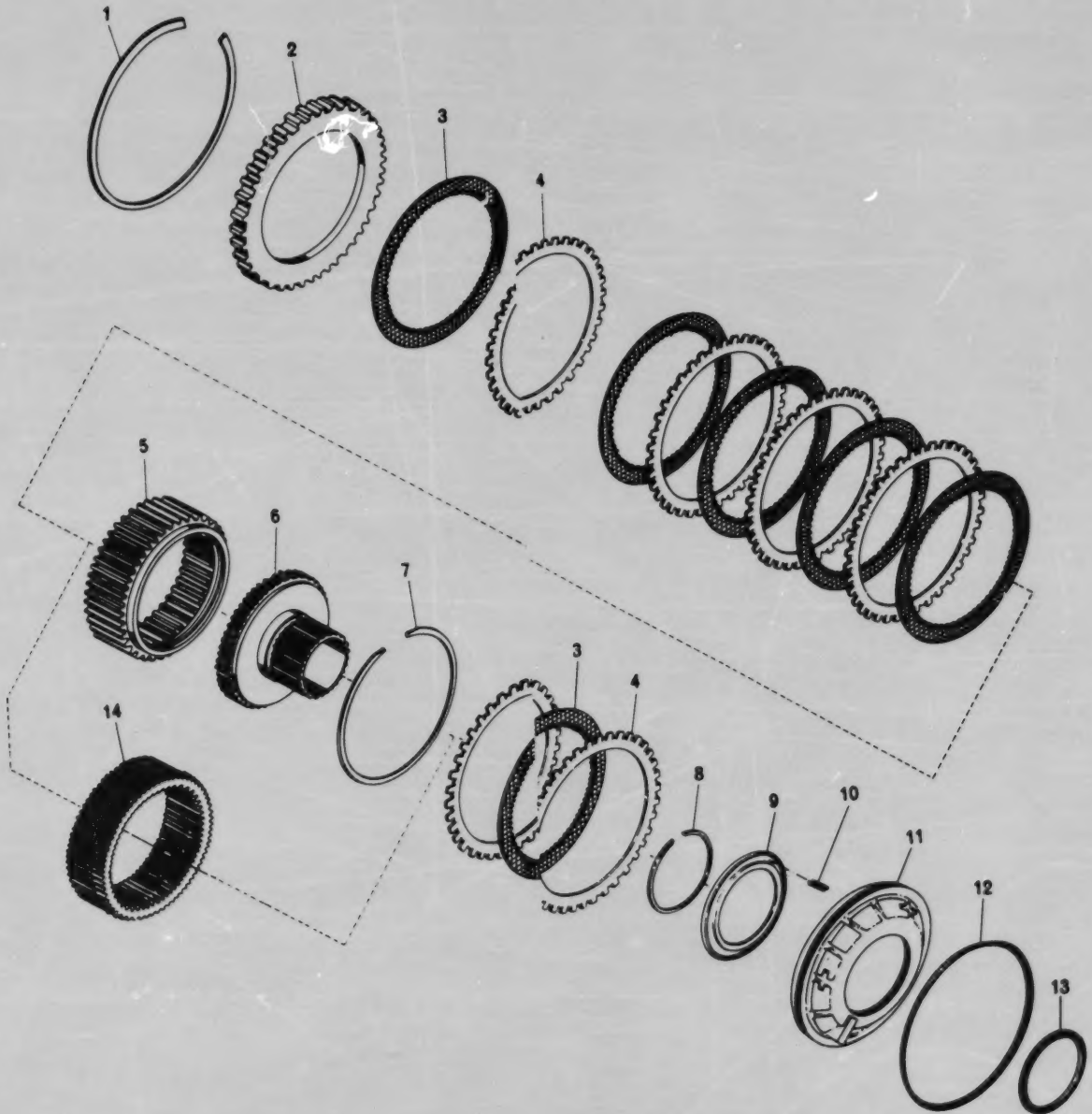
INSTRUCTOR CHECK: Procedure ☐ Safety ☐ Initials ☐

**JOB SHEET #17--PARTS LIST FOR FIRST CLUTCH AND REAR
PLANETARY RING GEARS (A)**

- 1 - Snapring
- 2 - First clutch back plate (ar):
 - 0.702—0.712 thk (No. 1)
 - 0.671—0.681 thk (No. 2)
 - 0.640—0.650 thk (No. 3)
- 3 - Internal-splined plate (6)
- 4 - External-tanged plate (6)
- 5 - Rear planetary ring gear (MT 650, 653)
- 6 - Rear planetary ring gear hub
(MT 650, 653)
- 7 - Snapring (MT 650, 653)
- 8 - Snapring
- 9 - Spring retainer
- 10 - Piston return spring (26)
- 11 - First clutch piston
- 12 - Piston outer sealring
- 13 - Piston inner sealring
- 14 - Rear planetary ring gear (MT 640, 643)

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JOB SHEET #17-EXPLODED VIEW OF FIRST CLUTCH AND REAR
PLANETARY RING GEARS (A)

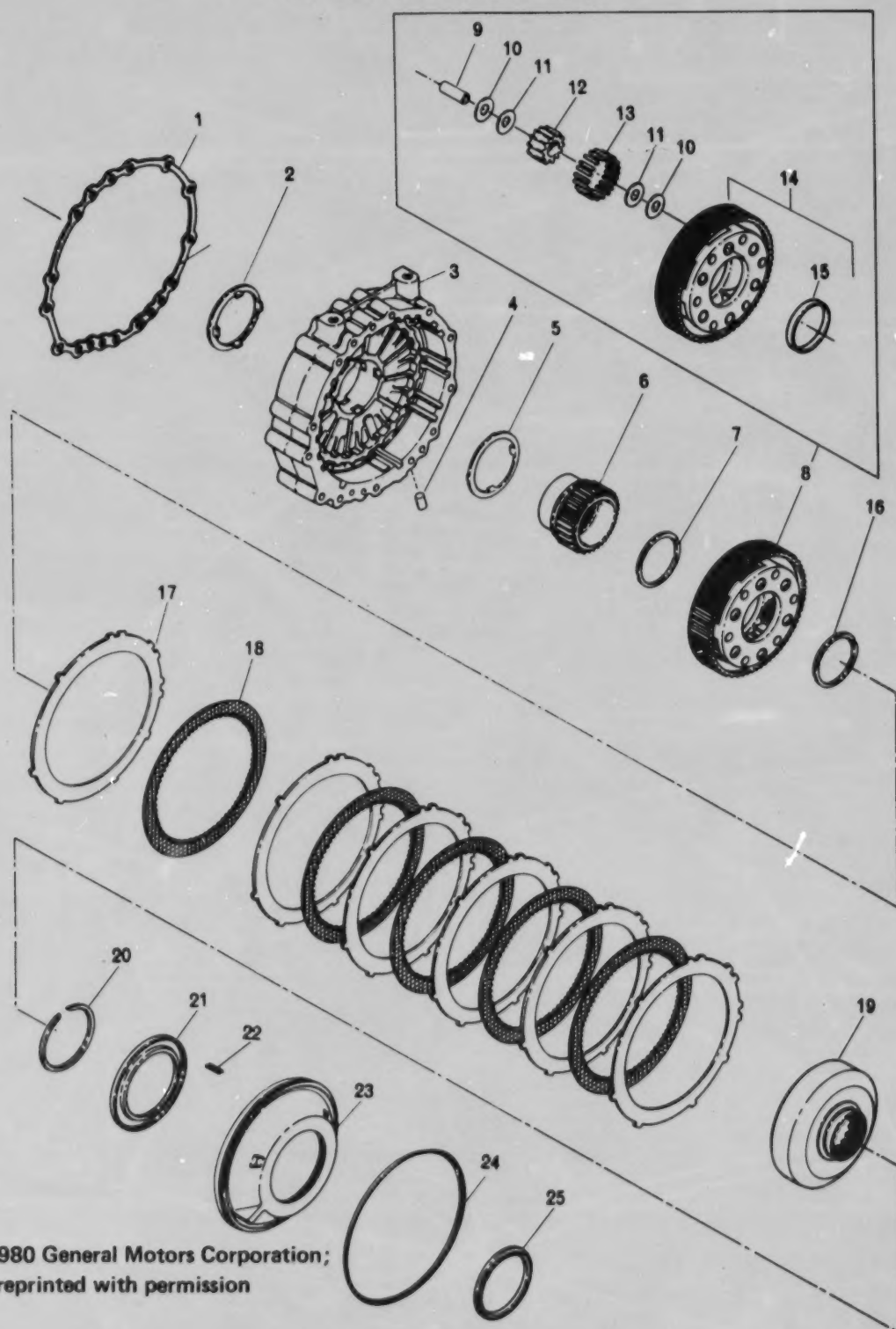


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JOB SHEET #17--PARTS LIST FOR LOW CLUTCH, PLANETARY,
AND ADAPTER HOUSING (B)

- 1 - Adapter housing gasket
- 2 - Thrust washer
- 3 - Adapter housing
- 4 - Hexagon socket plug, 1/4 in.
- 5 - Thrust washer
- 6 - Low sun gear
- 7 - Thrust washer
- 8 - Low-planetary carrier assembly
- 9 - Pinion pin (6)
- 10 - Bronze thrust washer (12)
- 11 - Steel thrust washer (12)
- 12 - Pinion (6)
- 13 - Pinion roller (114)
- 14 - Carrier and bushing assembly
- 15 - Bushing
- 16 - Thrust washer
- 17 - External-tanged plate (6)
- 18 - Internal-splined plate (5)
- 19 - Low-planetary ring gear
- 20 - Snapring
- 21 - Piston spring retainer
- 22 - Piston return spring (26)
- 23 - Low clutch piston (ar):
 - 0.858—0.868 thk (A)
 - 0.823—0.839 thk (B)
 - 0.800—0.810 thk (C)
- 24 - Piston outer sealring
- 25 - Piston inner sealring

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JOB SHEET #17--EXPLODED VIEW OF LOW CLUTCH, PLANETARY,
AND ADAPTER HOUSING (B)

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AUTOMATIC TRANSMISSIONS
UNIT V

JOB SHEET #18-DISASSEMBLE, CLEAN, INSPECT,
AND REASSEMBLE A TRANSMISSION HOUSING

I. Tools and materials

- A. Basic shop tools
- B. Clean shop towels
- C. Selector shaft seal remover
- D. Selector shaft seal installer
- E. Cleaning solvent in a clean container
- F. Compressed air supply for drying parts
- G. New gasket for valve adapter
- H. Socket-head bolts as required
- I. 100 foot-pound torque wrench
- J. Nonhardening sealer
- K. Appropriate service manual
- L. Safety glasses

II. Procedure

(NOTE: The following procedure and illustrations are adapted from materials published by Detroit Diesel Allison, © General Motors Corporation, and are reprinted with permission; this procedure may be modified by your instructor to facilitate available equipment.)

A. Disassemble the transmission housing with the following procedure:

1. Remove manual detent lever 34 by first removing shaft retainer pin 37 and nut 35

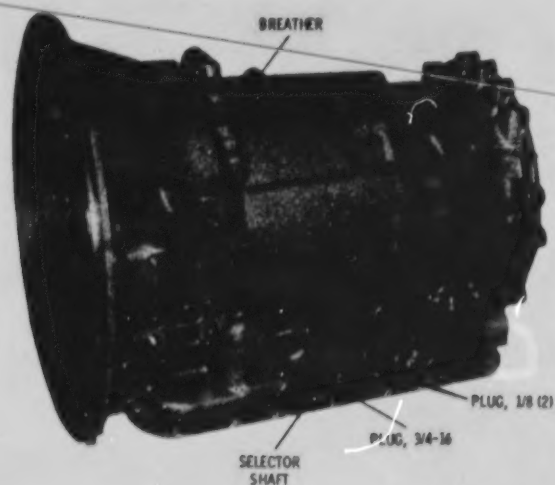
(NOTE: Refer to the parts list and exploded view that accompany this job sheet for parts identification.)

2. Hold the detent lever in one hand, and remove the shaft by carefully pulling it through the oil seal in the housing
3. Remove the detent lever
4. Remove oil seal 44 from the bore in the housing, using remover J-26401

JOB SHEET #18

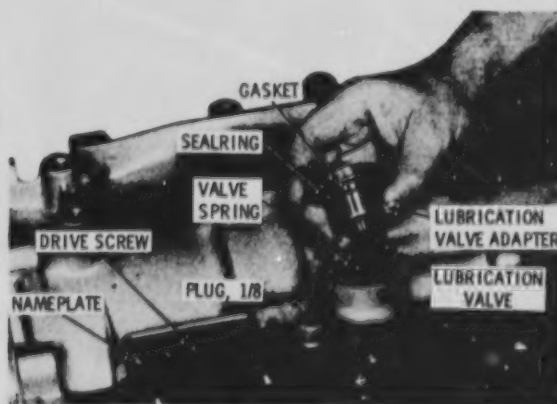
5. If replacement of the breather is necessary, use an open end wrench and rotate the breather counterclockwise (Figure 1)

FIGURE 1



6. Remove the breather
7. Remove the 3/4-16 plug and washer, or neutral switch, and the two 1/8-inch plugs only if necessary for cleaning internal passages
8. Remove two bolts, and washers if used, that retain the lubrication valve adapter (Figure 2)

FIGURE 2



9. Remove the adapter and discard the sealring and/or gasket
10. Remove the lubrication valve and spring

JOB SHEET #18

11. Remove the 1/8-inch plug (2 plugs on units with modulated lockup) from the right side of the transmission housing

12. Remove the nameplate only if it is necessary to replace it

(NOTE: All replacement parts orders require information from the nameplate, so it is imperative that the new nameplate be stamped with identical information to the nameplate that is replaced.)

13. Pull valve guide tube 12, pressed into the main housing on earlier models, from the housing if replacement is necessary

14. Clean and dry parts for inspection and reassembly

15. Inspect all parts for damage or excessive wear

B. Stop at this point and have your instructor check and initial your procedure and safe practice

INSTRUCTOR CHECK: Procedure ☐ Safety ☐ Initials ☐

C. Reassemble the transmission housing with the following procedure:

1. Install a new guide valve tube 13 if it was removed

2. Press the tube into its bore until it is 0.56 to 0.60 inch below the external surface of the adapter mounting boss

3. Replace the 1/8-inch plugs if they were removed

4. Tighten the plugs sufficiently to prevent leakage (Figure 2)

5. If a new nameplate is required, all information on the old plate must be metal stamped into the new plate

6. Install the new plate and retain it with a drive screw

7. Install the lubrication valve spring onto the tube in the housing bore (Figure 2)

8. Install the lubrication valve, convex side outward, onto the spring

9. Install a new gasket 8 onto the valve adapter

10. Install the adapter into the bore

11. Retain the adapter with two new 1/4-20 x 7/8-inch socket-head bolts

(NOTE: The bolts and lockwashers formerly used can be replaced with socket-head bolts when interference with hose-end fittings occurs; use bolts only one time.)

12. Tighten the bolts to 9-11 lb ft torque

JOB SHEET #18

13. If the 3/4-16 plug and washer, or neutral switch, or the two 1/8-inch plugs were removed, replace them
14. Tighten the 3/4-16 plug, or neutral switch, to 50-60 lb ft torque
15. Tighten the two 1/8-inch plugs sufficiently to prevent leakage
16. Place the selector shaft oil seal, sealing lip away from the tool, onto installer J-26282
17. Apply a nonhardening sealant onto the outer circumference of the oil seal
18. Install the seal into the housing bore (Figure 3)

FIGURE 3



19. Lubricate the inner bore of the seal

(NOTE: The revised configuration of the installer J-26282 permits installation of the oil seal with or without the selector shaft installed.)
20. Guide the grooved end of selector shaft 43 through seal 44 after removing burrs from shaft to protect oil seal
21. Position detent lever 34 so that the selector valve pin extends toward the inside of the housing, and engage the slot in the detent lever with flats on the selector shaft
22. Install nut 35 and retainer pin 37 to retrain the shaft and lever

JOB SHEET #18

23. Tighten the nut to 15-20 lb ft torque

(NOTE: See manufacturer's service manual for installation of the external selector lever.)

24. Install a new breather if the old one was removed

25. Tighten the breather sufficiently, using care not to distort or crush the breather stem

- D. Stop at this point and have your instructor check and initial your procedure and safe practice

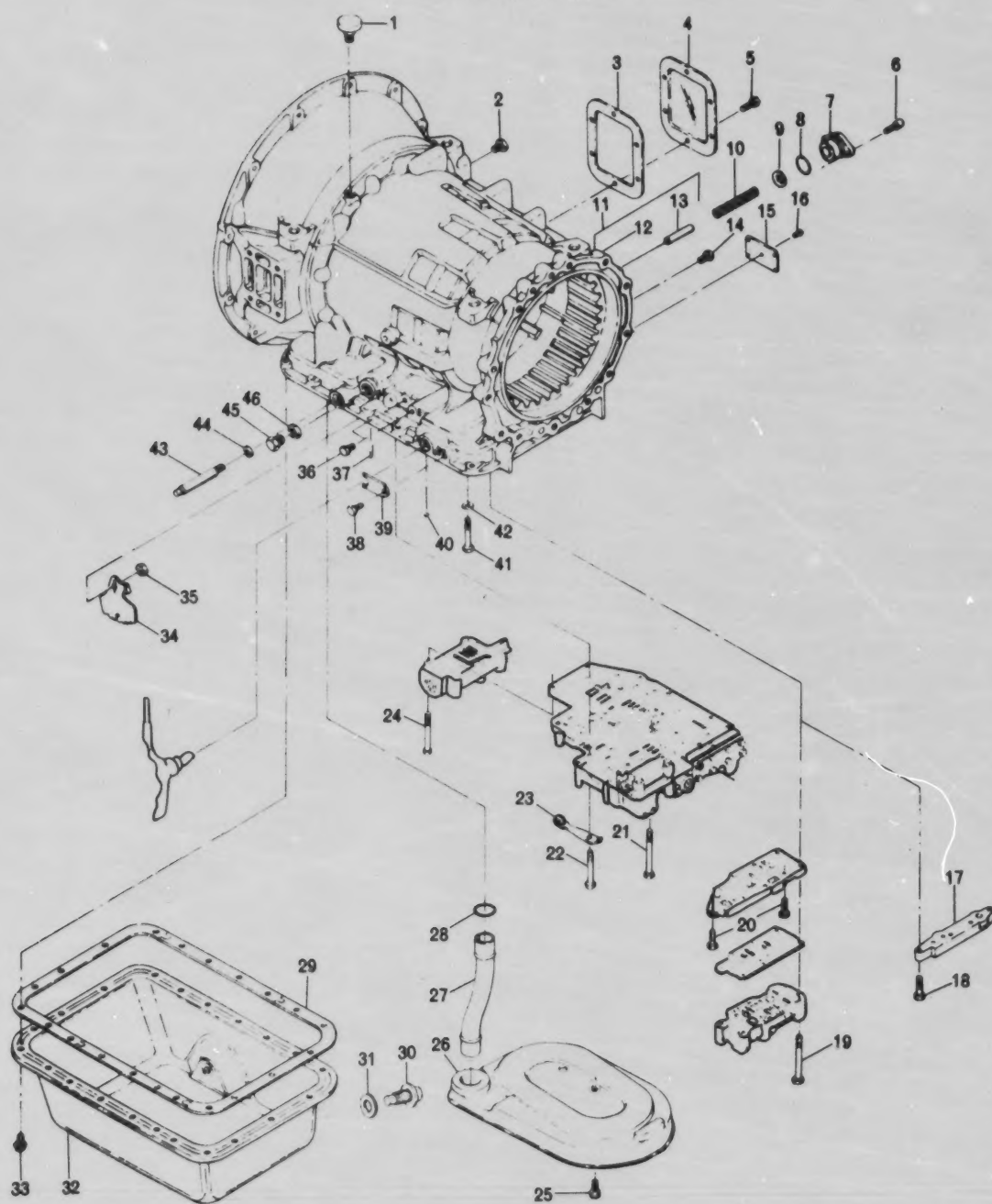
INSTRUCTOR CHECK: Procedure ☐ Safety ☐ Initials ☐

JOB SHEET #18-PARTS LIST FOR TRANSMISSION HOUSING,
OIL FILTER, AND PAN

- | | | |
|---|---|-----------------------------------|
| 1 - Breather | 17 - Tube adapter (MT 640, 643) | 32 - Oil pan |
| 2 - Modulated lockup check plug | 18 - Bolt, 1/4-20 x 1-1/4 (4) (MT 640, 643) | 33 - Washer head screw (21) |
| 3 - Gasket | 19 - Bolt, 1/4-20 x 2-3/4 (7) (MT 650, 653) | 34 - Inside detent lever |
| 4 - Power takeoff cover | 20 - Bolt, 1/4-20 x 7/8 (2) (MT 650, 653) | 35 - Nut, 3/8-24 |
| 5 - Bolt, 3/8-16 x 3/4 (6) | 21 - Bolt, 1/4-20 x 2-1/4 (18) | 36 - Plug, 1/8 (2) |
| 6 - Bolt, 1/4-20 x 7/8 (2) | 22 - Bolt, 1/4-20 x 1-3/4 | 37 - Shaft retainer pin |
| 7 - Lubrication regulator valve adapter | 23 - Detent roller and spring assembly | 38 - Bolt, 5/16-18 x 9/16 |
| 8 - Gasket | 24 - Bolt, 1/4-20 x 1-3/4 (4) | 39 - Modulator retainer |
| 9 - Lubrication regulator valve | 25 - Washer head screw 5/16-18 | 40 - Governor pressure check ball |
| 10 - Valve spring | 26 - Oil Filter | 41 - Bolt, 3/8-16 x 2-1/4 |
| 11 - Transmission housing assembly | 27 - Oil filter tube | 42 - Plain washer, 3/8 |
| 12 - Housing | 28 - Sealring | 43 - Manual selector shaft |
| 13 - Valve guide tube | 29 - Oil pan gasket | 44 - Selector shaft oil seal |
| 14 - Plug, 1/8 | 30 - Drain plug | 45 - Plug, 3/4 |
| 15 - Name plate | 31 - Gasket | 46 - Washer |
| 16 - Drive screw | | |

* Earlier models used two external hex head bolts and two washers.

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JOB SHEET #18-EXPLODED VIEW OF TRANSMISSION HOUSING,
OIL FILTER, AND PAN

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AUTOMATIC TRANSMISSIONS
UNIT V

JOB SHEET #19--REASSEMBLE AN AUTOMATIC TRANSMISSION

- I. Tools and materials
 - A. Center support lifter
 - B. Front support lifter
 - C. Hoist
 - D. Depth micrometer
 - E. First, second, and third clutch clearance gauges
 - F. Torque converter lifter and converter retaining strap
 - G. Snapping gauge
 - H. Compressor base, compressor bar, and compressor screw
 - I. Gear unit lifter
 - J. Rear bearing installer
 - K. Oil seal installer
 - L. Dust shield installer
 - M. Oil-soluble and high-temperature grease
 - N. Self-locking anchor bolt
 - O. Guide bolts and headless guide screws
 - P. Bolts and rubber-covered washers as required
 - Q. New 3/8-16 x 2 1/4-inch self-locking bolt and washer
 - R. Washer-head screws as required
 - S. Compressed air supply
 - T. 100 foot-pound torque wrench
 - U. Basic shop tools
 - V. Cleaning solvent in a clean container
 - W. Clean shop towels
 - X. Nonhardening sealer

JOB SHEET #19

Y. Appropriate service manual

Z. Safety glasses

II. Procedure

(NOTE: The following procedure and illustrations are adapted from materials published by Detroit Diesel Allison, © General Motors Corporation, and are reprinted with permission; this procedure may be modified by your instructor to facilitate available equipment.)

A. Select center support snapping with the following procedure:

1. Position the transmission housing, converter end up, and install the second clutch back plate 27
2. Beginning with an internal-splined clutch plate, alternately install three internal-splined 26 and three external-splined 25 clutch plates into the transmission housing
3. Retain the plates with snapping 24

(NOTE: Refer to the parts lists and exploded views that accompany previous job sheets for parts identification.)

4. Remove third clutch piston 10 from center support assembly 14
5. Attach center support lifter J-24455 into the recess between the sealrings on the support hub (Figure 1)

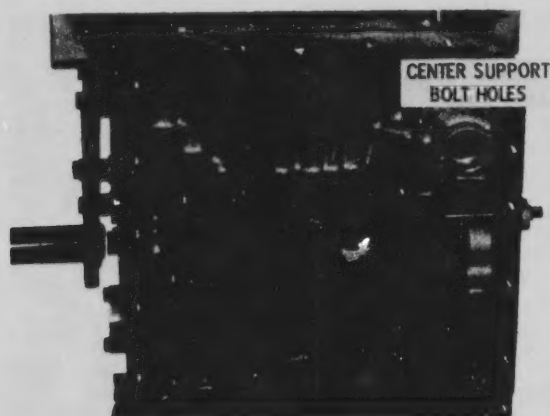
FIGURE 1



JOB SHEET #19

6. Align the tapped hole in the support (Figure 1) with the anchor bolt hole in the transmission housing (Figure 2)

FIGURE 2

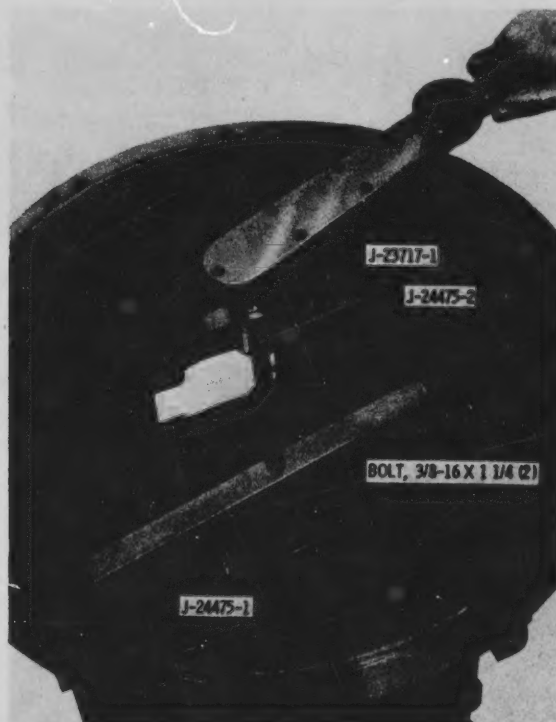


7. Lower the support carefully into the housing, seating it firmly against the second clutch retaining snapping
8. Remove the lifting bracket from the support
9. Retain the support by installing the special 3/8-16 x 2 1/4-inch self-locking anchor bolt and washer
10. Tighten the bolt finger tight

JOB SHEET #19

11. Install compressor base J-24475-1 over the hub of the center support (Figure 3)

FIGURE 3

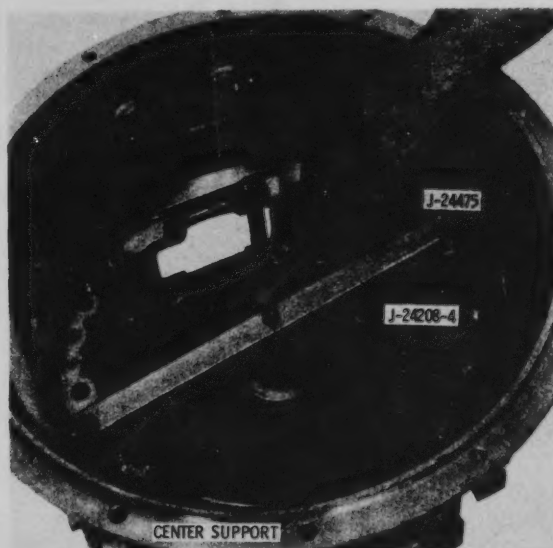


12. Install compressor bar J-24475-2 and screw J-23717-1, retaining the bar to the transmission with two 3/8-16 x 1 1/4-inch bolts (Figure 3)
13. Compress the support by applying a torque of 5 pound feet to screw J-23717-1

JOB SHEET #19

14. Using gauge J-24208-4, measure the clearance between the top edge of the center support and the top of the snapping groove in the housing (Figure 4)

FIGURE 4



15. Select the proper snapping, using the following table:

Measured Clearance	Snapping Thickness	Snapping Color
0.150-0.154	0.148-0.150	Blue
0.154-0.157	0.152-0.154	Yellow
0.157-0.160	0.155-0.157	Green
0.160-0.164	0.158-0.160	Red

16. Install the selected snapping and remove the compressor from the housing
- B. Stop at this point and have your instructor check and initial your procedure and safe practice

INSTRUCTOR CHECK: Procedure ☐ Safety ☐ Initials ☐

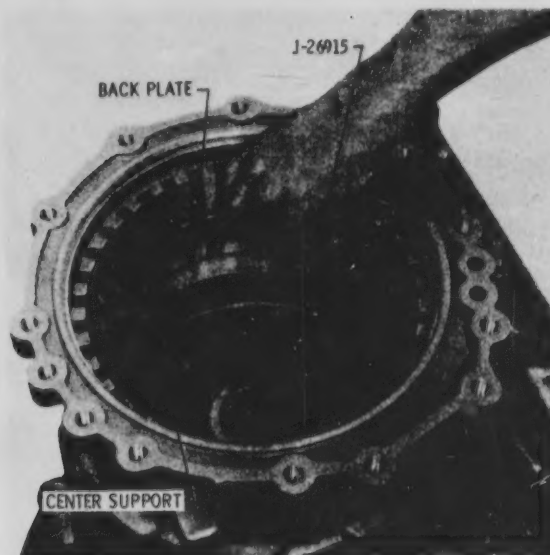
- C. Check second clutch clearance with the following procedure:

1. Invert the transmission housing, output end upward
2. Using gauge J-26915, check the second clutch plate clearance

JOB SHEET #19

3. Insert the gauge between the back plate and the transmission housing (Figure 5)

FIGURE 5



4. Measure to see that the prescribed clearance of 0.049 to 0.111 is achieved

(NOTE: When prescribed clearance is achieved, the first step of the gauge will fit between the back plate and the transmission housing; the second step will not.)

5. If the clearance is not satisfactory, measure the total plate thickness, and replace all plates necessary to satisfy the prescribed clearance

(NOTE: If required, the back plate may be replaced by a thicker or thinner plate.)

- D. Stop at this point and have your instructor check and initial your procedure and safe practice

INSTRUCTOR CHECK: Procedure ☐ Safety ☐ Initials ☐

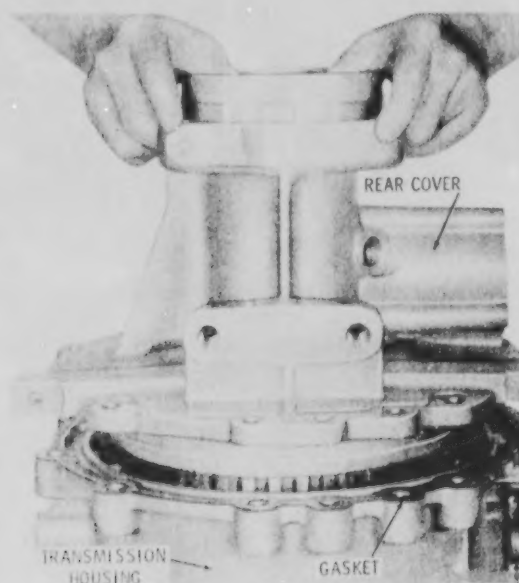
JOB SHEET #19

E. Install rear cover and first clutch with the following procedure:

1. Place the rear cover gasket on the transmission housing, aligning the holes in the gasket with those in the housing (Figure 6)

(NOTE: This procedure applies to Allison models MT 640 and 643; check with your instructor if you have questions concerning this step in the procedure.)

FIGURE 6



2. Install the rear cover assembly (as completed in a previous job sheet) onto the transmission housing (Figure 6)
3. Install fourteen 1/2-13 x 1 1/2-inch bolts and washers to retain the rear cover assembly
4. Tighten two bolts that are 180° apart to 33 lb ft torque
5. Move approximately 90° around the bolt circle and repeat the tightening operation
6. Tighten the remaining bolts at 180° increments to 33 lb ft torque
7. Repeat the entire process, tightening each of the fourteen bolts to 67-80 lb ft torque
8. Begin installation of the first clutch by inverting the transmission front side up

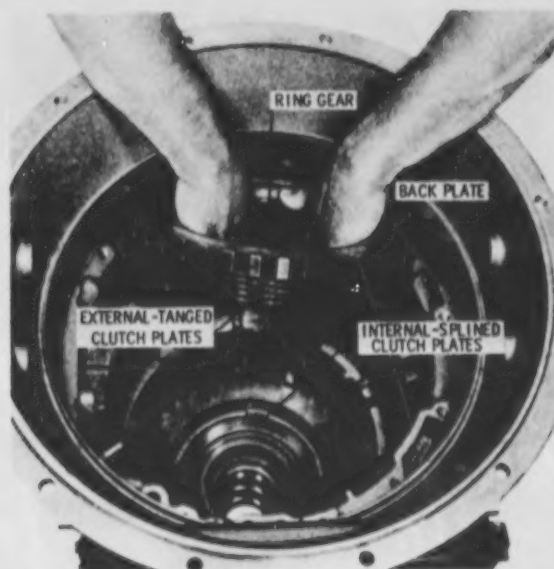
JOB SHEET #19

9. Remove the snapping that retains the center support
10. Remove the center support anchor bolt and washer
11. Attach center support lifter J-24455 to the hub of the support (Figure 1)
12. Remove the center support from the transmission
13. Remove the lifting bracket from the center support
14. Remove the second clutch retaining snapping
15. Remove the six second clutch plates and the back plate from the transmission housing
16. Retain the second clutch plates in a pack; do not mix them in with other plates
17. Install one external-tanged, one internal-splined, and one external-tanged first clutch plates into the transmission housing
18. Place the rear planetary ring gear, extended tooth side down, on the work table
19. Beginning with an internal-splined clutch plate, install five internal-splined and four external-tanged clutch plates and the back plate, flat side first, onto the ring gear

JOB SHEET #19

20. Install the ring gear and plates as an assembly into the transmission housing (Figure 7)

FIGURE 7



21. Retain the first clutch plate pack with a snapping (Figure 8)

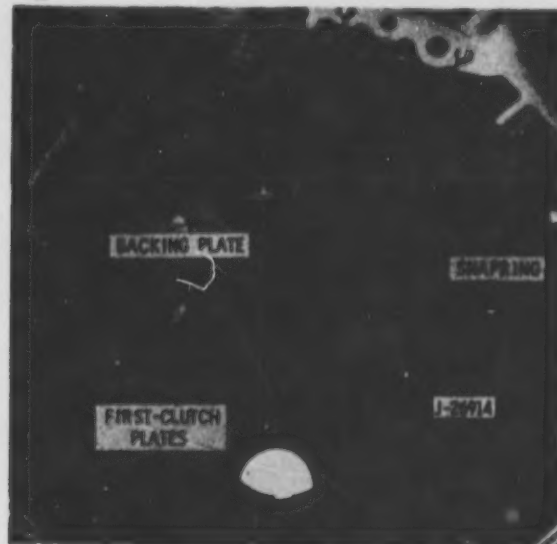
FIGURE 8



JOB SHEET #19

22. Using first clutch clearance gauge J-26914, check the clearance between the snapping and back plate (Figure 9)

FIGURE 9



23. Measure to see that the prescribed clearance of 0.074 to 0.147 inch for the first clutch is achieved

(NOTE: When prescribed clearance is achieved, the first step of the gauge will fit between the snapping and back plate; the second step will not.)

24. If the clearance is not satisfactory, measure the total plate thickness, and replace all plates necessary to satisfy the prescribed clearance

(NOTE: If required, the back plate may be replaced by a thicker or thinner plate.)

- F. Stop at this point and have your instructor check and initial your procedure and safe practice

INSTRUCTOR CHECK: Procedure ☐ Safety ☐ Initials ☐

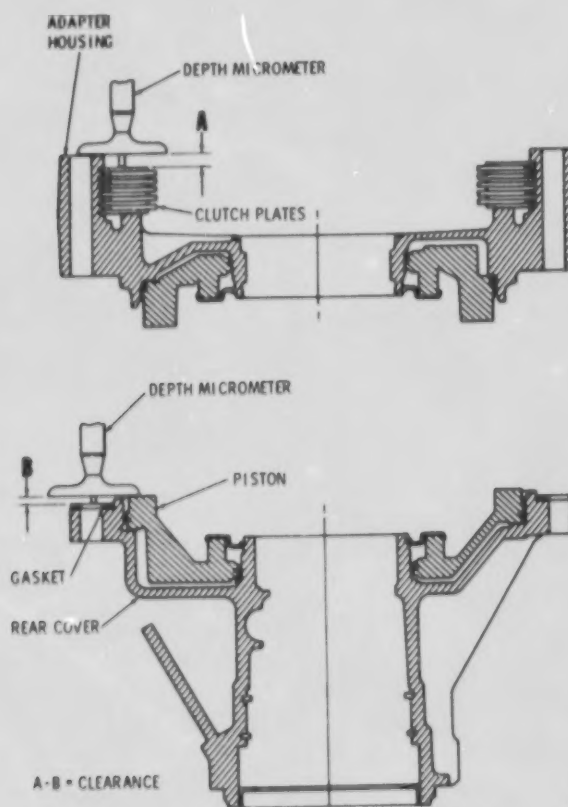
JOB SHEET #19

G. Establish low clutch clearance with the following procedure:

(NOTE: This procedure is for Allison models MT 650 and 653.)

1. Position the adapter housing and first clutch pistons (as assembled in a previous job sheet) on a clean work surface, piston downward (Figure 10)

FIGURE 10



2. Install the low-clutch plates, six external-tanged plates, five internal-splined plates, into the adapter housing (Figure 10)
3. Position the rear cover (as assembled in a previous job sheet) on a clean work surface, piston upward, and install the rear cover gasket (Figure 10)
4. Using a depth micrometer as shown in Figure 10, measure and record dimension A, distance from top of housing to top clutch plate
5. Use firm hand pressure against the plates at the point of measurement

JOB SHEET #19

6. Using a depth micrometer as shown in Figure 10, measure and record dimension B, distance from top of piston to gasket mounting flange
7. Subtract dimension B from dimension A to obtain clearance of low clutch

(NOTE: The clearance is acceptable if it is within 0.081 to 0.139 inch; however, the closer the clearance is to 0.081, the longer the life of the clutch pack.)

8. Replace worn plates with new plates to obtain desired running clearance

(NOTE: If the adapter housing or rear cover was replaced, it may be necessary to select a piston with a different thickness to obtain the desired clearance.)

9. After a desired clearance is established, remove and identify the low clutch pack

- H. Stop at this point and have your instructor check and initial your procedure and safe practice

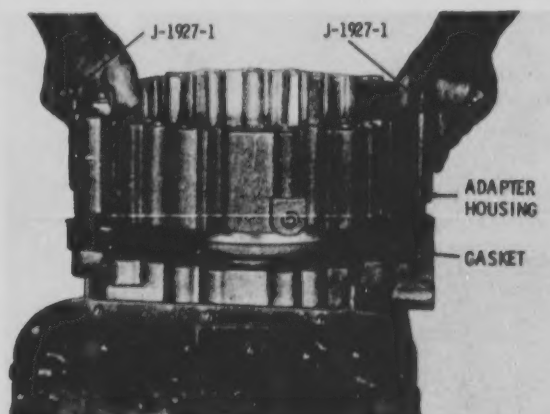
INSTRUCTOR CHECK: Procedure ☐ Safety ☐ Initials ☐

- I. Install the low clutch with the following procedure

(NOTE: This procedure is for Allison models 650 and 653.)

1. Install the adapter housing gasket onto the rear of the transmission housing (Figure 11)

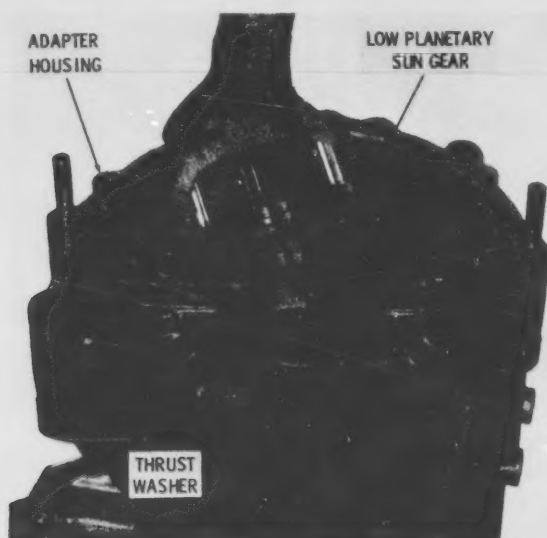
FIGURE 11



JOB SHEET #19

2. Install the adapter housing and first clutch piston (as assembled in a previous job sheet)
3. Use 1/2-13 x 6-inch guide bolts J-1927-1 to maintain gasket alignment during assembly
4. Install the tanged thrust washer and low planetary sun gear (Figure 12)

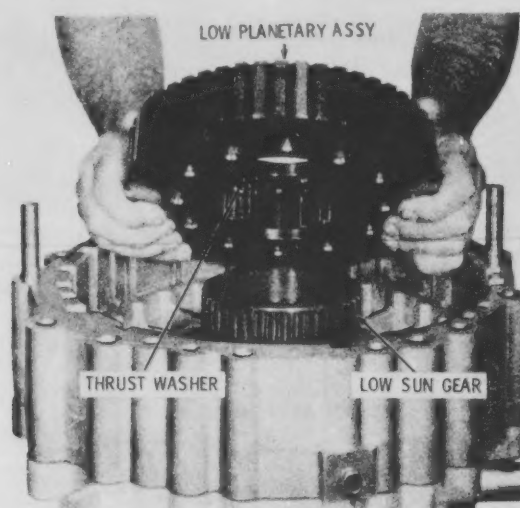
FIGURE 12



JOB SHEET #19

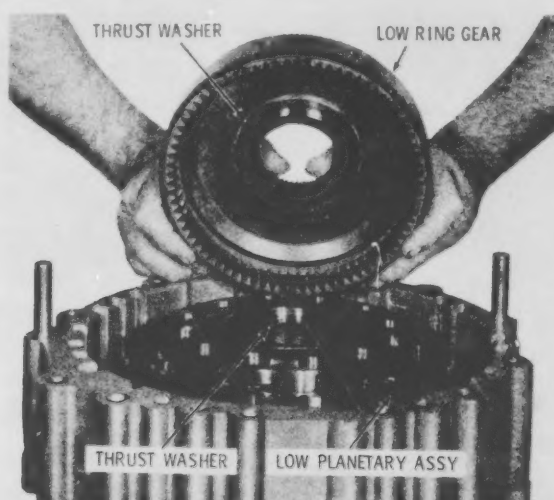
5. Install the thrust washer into the low planetary assembly and retain it with oil-soluble grease (Figure 13)

FIGURE 13



6. Install the planetary assembly (as assembled in a previous job sheet) onto the planetary sun gear (Figure 13)
7. Install the thrust washer onto the hub of the low ring gear and retain it with oil-soluble grease (Figure 14)

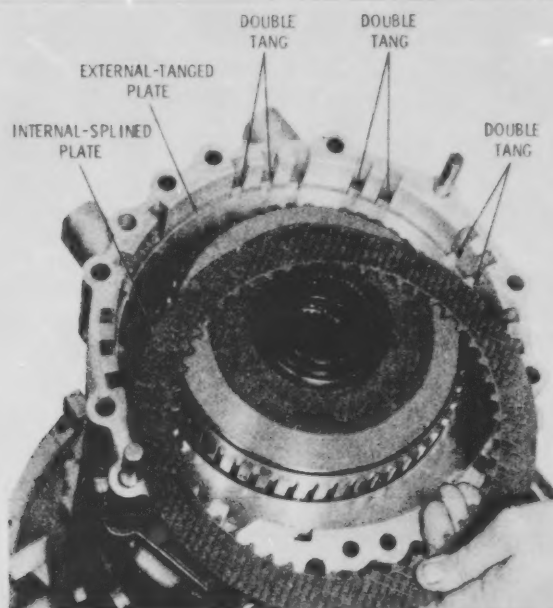
FIGURE 14



JOB SHEET #19

8. Center the thrust washer within the planetary assembly, and install the ring gear (Figure 14)
9. Beginning with an external-tanged plate, install the low clutch pack into the adapter housing
10. Pay particular attention to the positioning of the three sets of double tangs on the plates; if the tangs are not positioned as shown in Figure 15, movement of the stationary plates will occur

FIGURE 15



JOB SHEET #19

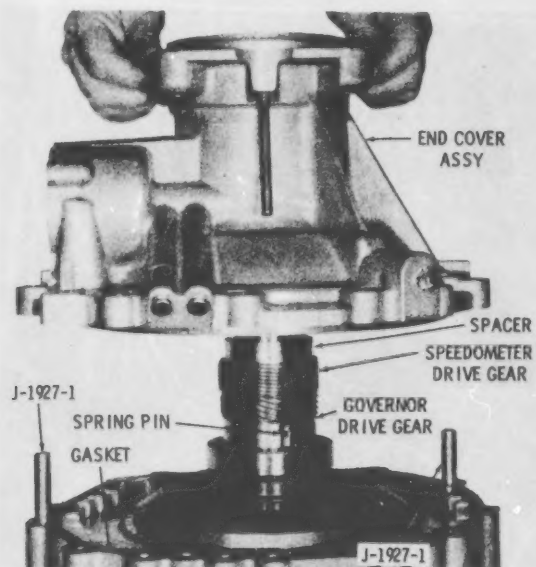
11. Install the output shaft assembly (as assembled in a previous job sheet) into the low ring gear (Figure 16)

FIGURE 16



12. If the governor drive gear was not previously installed, install it onto the output shaft, and engage the spring pin with the slot in the drive gear (Figure 17)

FIGURE 17



13. Install the speedometer drive gear and spacer onto the output shaft

JOB SHEET #19

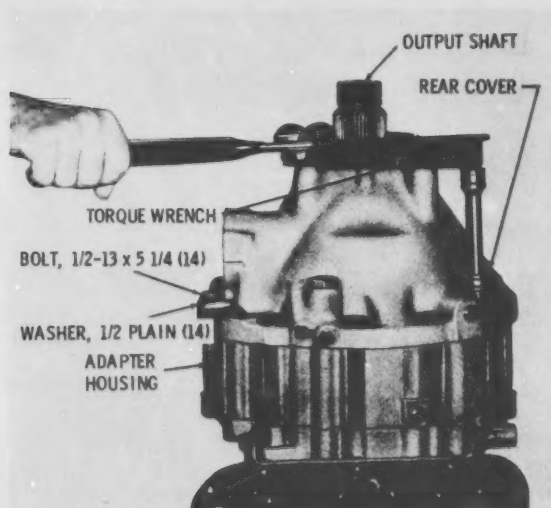
- J. Stop at this point and have your instructor check and initial your procedure and safe practice

INSTRUCTOR CHECK: Procedure ☐ Safety ☐ Initials ☐

- K. Install the rear cover with the following procedure:

1. Install the rear cover gasket onto the adapter housing as shown in Figure 17
2. Install the rear cover assembly (as assembled in a previous job sheet) onto the adapter housing (Figure 17)
3. Install twelve 1/2-13 x 5 1/4-inch bolts and washers, through the rear cover and adapter housing, into the transmission housing (Figure 18)

FIGURE 18

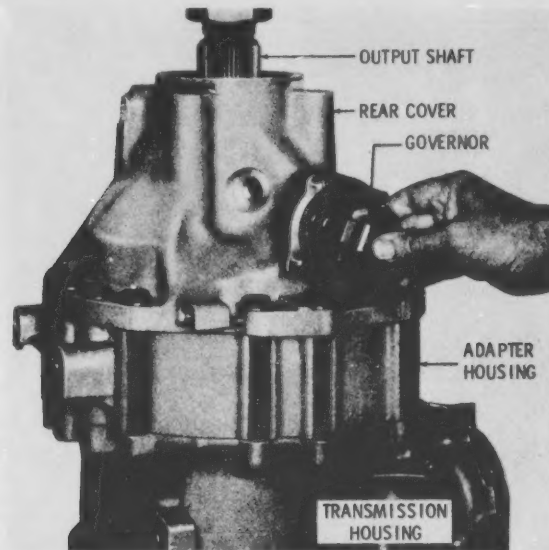


4. Replace the two guide bolts with the two remaining cover bolts and washers
5. Tighten two bolts that are 180° apart to 33 lb ft torque
6. Move approximately 90° around the bolt circle and repeat the operation
7. Tighten the remaining opposite pairs of bolts to 33 lb ft torque
8. Repeat the entire process, tightening all fourteen bolts to 67-80 lb ft torque

JOB SHEET #19

9. Install the governor into the rear cover assembly (Figure 19)

FIGURE 19



10. Install the governor cover gasket and the cover onto the rear cover assembly
11. Retain the governor cover with four 5/16-18 x 9/16-9 inch bolts
12. Tighten the bolts to 15-20 lb ft torque

(NOTE: Check with the service manual to see if an output flange spacer is required, and refer to the manual for installation of the output flange retaining nut.)

- L. Stop at this point and have your instructor check and initial your procedure and safe practice

INSTRUCTOR CHECK: Procedure ☐ Safety ☐ Initials ☐

- M. Install the first clutch with the following procedure:

1. Invert the transmission, front side upward
2. Remove the center support anchor bolt and washer

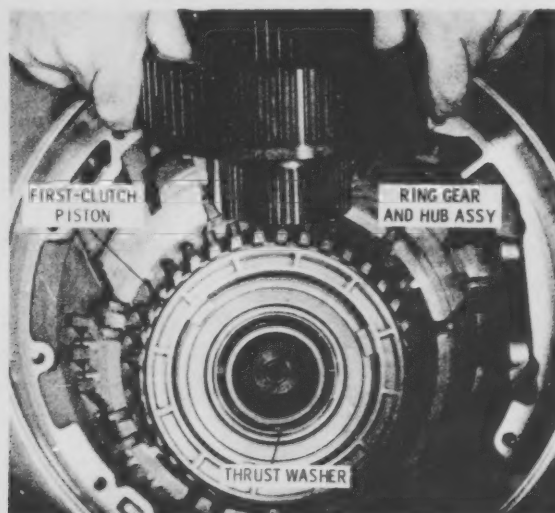
(NOTE: It may be necessary to compress the center support in order to remove the snapring.)

3. Attach center support lifting bracket J-24455 to the hub of the support

JOB SHEET #19

4. Remove the center support
5. Remove the second clutch plate retaining snapping
6. Remove the six second clutch plates and back plate from the transmission housing
7. Retain the second clutch plates in a pack; do not mix them with other plates
8. Install ring gear hub 6 into ring gear 5 and retain it with snapping 7
9. Install the tanged thrust washer into the hub of the adapter housing (Figure 20)

FIGURE 20

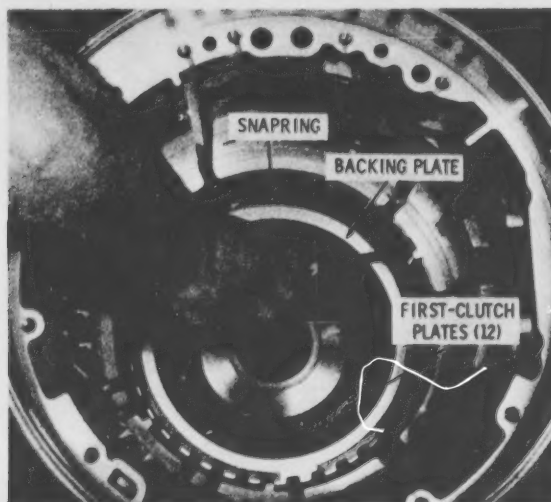


10. Install the rear planetary ring gear and hub assembly
11. Starting with an external-tanged plate, alternately install six external-tanged and six internal-splined clutch plates

JOB SHEET #19

12. Install the back plate, flat side first, and retain it with the snapping (Figure 21)

FIGURE 21



13. Using first clutch gauge J-26914, check the clearance between the snapping and the ack plate as shown in Figure 9
14. Measure to see that the prescribed clearance of 0.074 to 0.147-inch is achieved
- (NOTE: When prescribed clearance is achieved, the first step of the gauge will fit between the snapping and the back plate; the second step will not.)
15. If the clearance is not satisfactory, measure the total plate thickness, and replace all plates necessary to satisfy the prescribed clearance
- (NOTE: If required, the back plate may be replaced by a thicker or thinner plate.)
- N. Stop at this point and have your instructor check and initial your procedure and safe practice

INSTRUCTOR CHECK: Procedure ☐ Safety ☐ Initials ☐

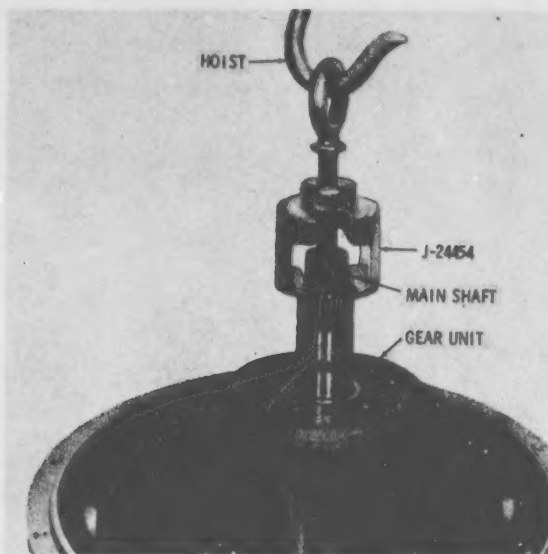
JOB SHEET #19

- O. Install the gear unit with the following procedure:

(NOTE: This procedure is for Allison models MT 650 and 653.)

1. Attach gear unit lifter J-24454 behind the splines of the main shaft (Figure 22)

FIGURE 22



2. Be sure that thrust washer 47 is retained by oil-soluble grease to rear carrier assembly 38
3. Using a hoist, carefully lower the gear unit (as assembled in a previous job sheet) into the transmission housing (Figure 22)
4. Engage the internal splines of the rear planetary carrier assembly hub with the splines of the output shaft, and the pinions of the rear carrier assembly with the teeth of the rear planetary ring gear

(NOTE: On Allison models 640 and 643, this procedure, after lowering the gear unit into the transmission housing, requires engagement of the pinions of the rear planetary carrier assembly with the teeth of the rear planetary ring gear.)

- P. Stop at this point and have your instructor check and initial your procedure and safe practice

INSTRUCTOR CHECK: Procedure ☐ Safety ☐ Initials ☐

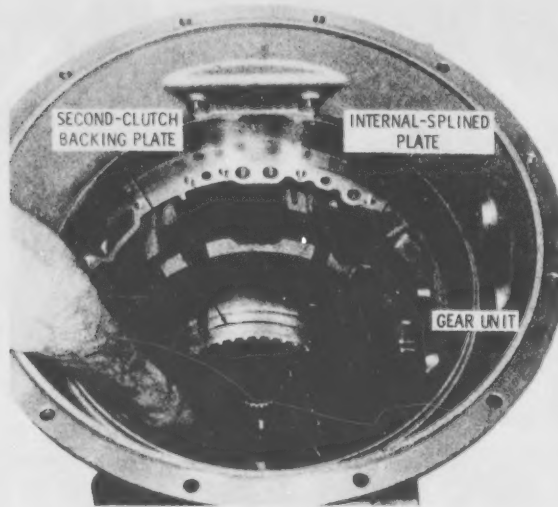
JOB SHEET #19

Q. Install the second clutch with the following procedure:

(NOTE: Prior to installation of the second clutch, be sure the clutch pack satisfies the required clearance.)

1. Install the second clutch pack into the transmission (Figure 23)

FIGURE 23

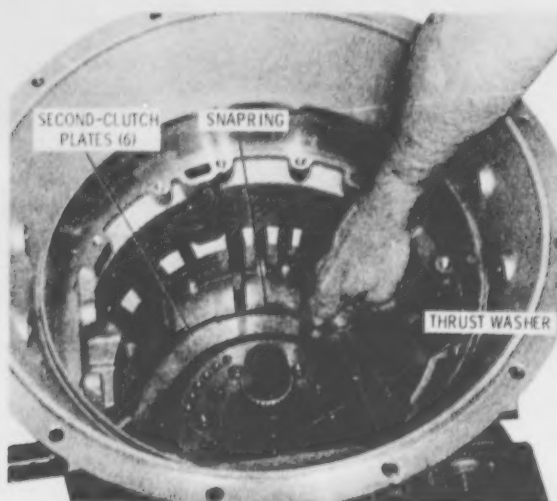


2. Install second clutch back plate 27
3. Beginning with an internal-splined plate 26, alternately install three plates 26 and three plates 25

JOB SHEET #19

4. Install the snapring to retain the second clutch (Figure 24)

FIGURE 24



5. Be sure the thrust washer is in place on the front sun gear

- R. Stop at this point and have your instructor check and initial your procedure and safe practice

INSTRUCTOR CHECK: Procedure ☐ Safety ☐ Initials ☐

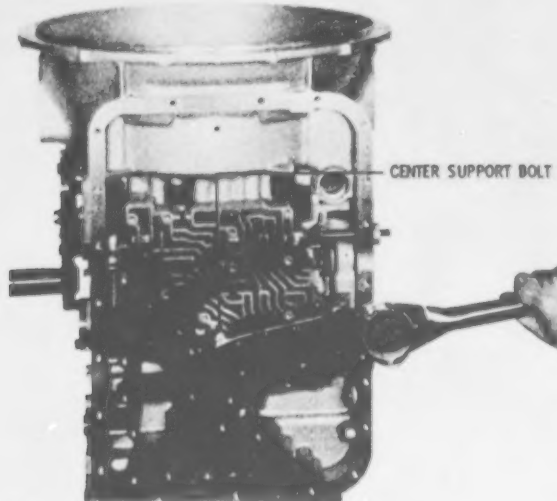
- S. Install the center support with the following procedure:

1. Install the third clutch piston, as previously assembled, into the center support
2. Use care to ensure that the piston sealrings are not pinched nor distorted when the piston is installed
3. Attach center support lifter J-24455 into the recess between the sealring grooves on the support hub (Figure 1)
4. Align the tapped hole in the support (Figure 1) with the anchor bolt in the transmission housing (Figure 2)
5. Arrange the gap of the second clutch snapring so it will be between any two of the four tangs on the second clutch spring retainer ring 22
6. Install the center support (as reassembled in a previous job sheet) and seat it firmly against the second clutch snapring

JOB SHEET #19

7. Remove the lifter form the center support
8. Start a new 3/8-16 x 2 1/4-inch special self-locking bolt and washer into the center support assembly
9. Install the snapping, previously selected, to retain the center support
10. Place the snapping gap between any two retainer ring tangs
11. Tighten the center support anchor bolt to 39-46 lb ft torque (Figure 25)

FIGURE 25



12. Install needle roller bearing assembly 16, rollers upward, onto the center support hub
 13. Install two step-joint sealrings 13 onto the hub, and retain them with oil-soluble grease
- T. Stop at this point and have your instructor check and initial your procedure and safe practice

INSTRUCTOR CHECK: Procedure ☐ Safety ☐ Initials ☐

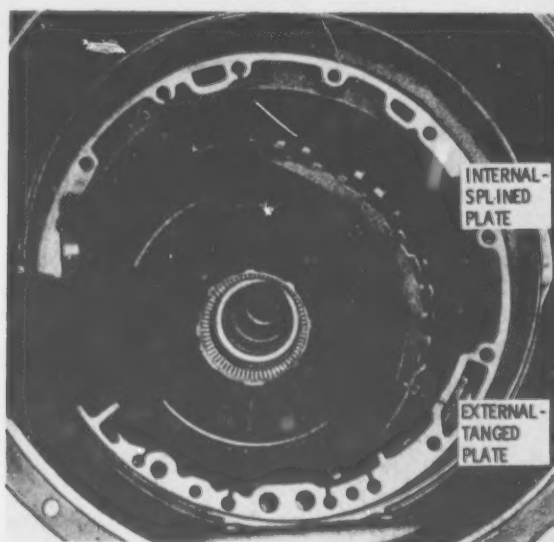
JOB SHEET #19

U. Check third clutch clearance and install third and fourth clutches with the following procedure:

1. Begin third clutch assembly and check by starting with an external-tanged plate as shown in Figure 26, and alternately install the three external-tanged plates and three internal-splined plates

(NOTE: Pay attention to the location of the three sets of double tangs; if the tangs are not positioned as shown, movement of the stationary plates will occur.)

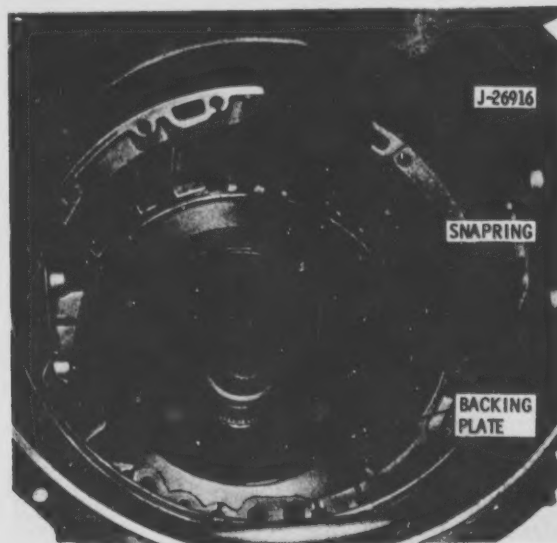
FIGURE 26



JOB SHEET #19

2. Install the back plate and retain it with the snapping (Figure 27)

FIGURE 27



3. Using third clutch clearance gauge J-26916, check between the snapping and back plate
4. Measure to see that the prescribed clearance of 0.050 to 0.114-inch is achieved

(NOTE: When prescribed clearance is achieved, the first step of the gauge will fit between the snapping and back plate; the second step will not.)

5. If the clearance is not satisfactory, measure the total plate thickness, and replace all plates necessary to satisfy the prescribed clearance

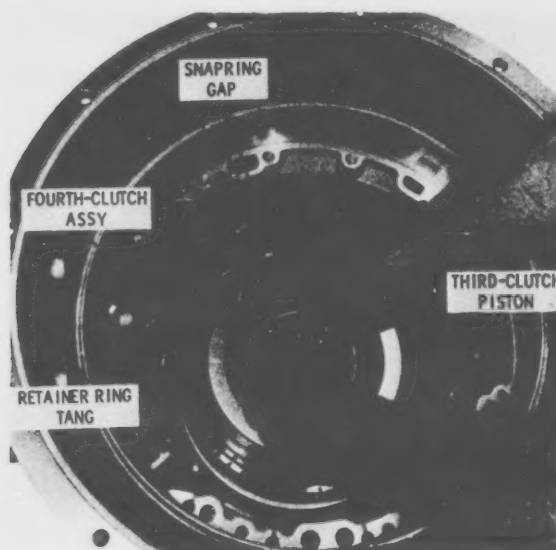
(NOTE: If required, the back plate may be replaced by a thicker or thinner plate.)

6. Be sure the needle bearing race is in place on the rear of the fourth clutch housing hub
7. Align the internal splines of the third clutch plates to the external splines on the fourth clutch housing

JOB SHEET #19

8. Grasp the fourth clutch assembly (as reassembled in a previous job sheet) by the spring retainer, and install it into the center support hub (Figure 28)

FIGURE 28



- V. Stop at this point and have your instructor check and initial your procedure and safe practice

INSTRUCTOR CHECK: Procedure ☐ Safety ☐ Initials ☐

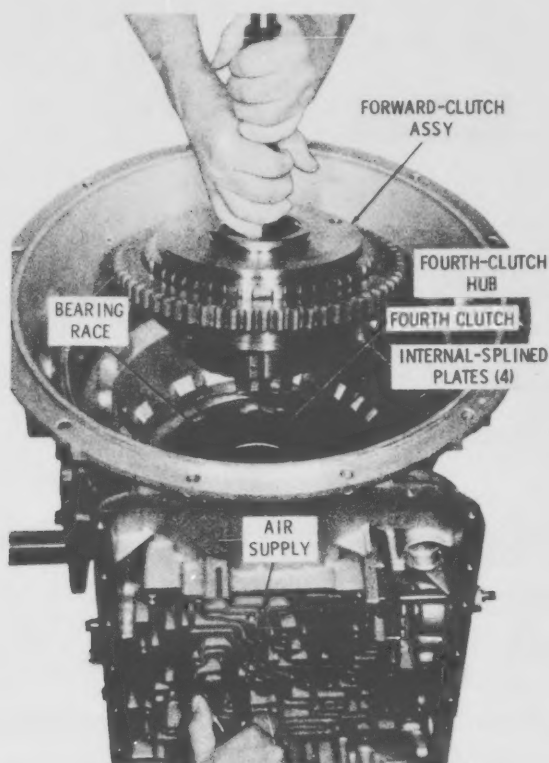
JOB SHEET #19

W. Install forward clutch, oil pump, and front support with the following procedure:

1. Align the internal-splined plates of the fourth clutch, and direct air into the fourth clutch apply port (Figure 29)

(NOTE: The air will apply the fourth clutch and prevent movement of the clutch plates during installation of the forward clutch assembly.)

FIGURE 29



2. Be sure the needle bearing and race are securely in place on the forward clutch hub (refer to Figure 6 in Job Sheet #10, if necessary) and the mating race is in place on the hub of the fourth clutch housing (Figure 29)
3. Install the forward clutch assembly (as reassembled in a previous job sheet) while engaging the fourth clutch hub within the internal-splined plates of the fourth clutch housing (Figure 29)

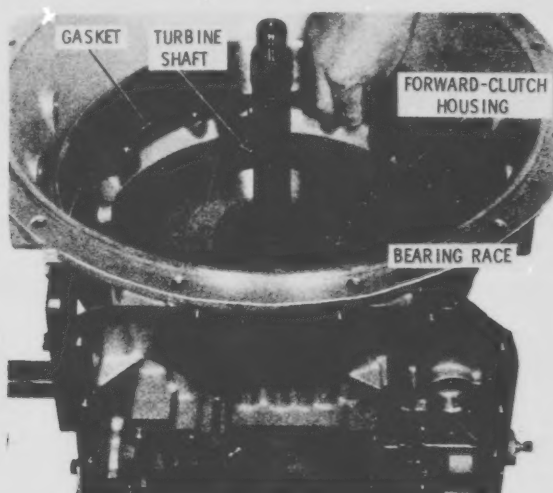
JOB SHEET #19

4. Make sure forward clutch assembly is properly seated; it should be approximately 1/2-inch behind the forward edge of the PTO opening

(NOTE: Another check is to apply air in short bursts to the fourth clutch and watch the forward clutch assembly for an up and down movement; if the assembly does not move, it is properly seated.)

5. Install the front support gasket (FIGURE 30)

FIGURE 30

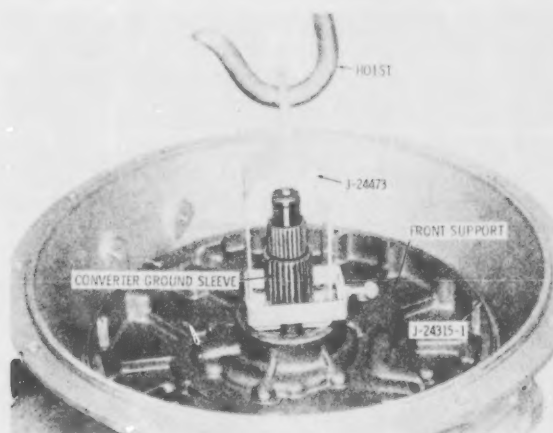


6. Be sure the two sealrings at the base of the turbine shaft are held in place with oil-soluble grease
7. Install bearing and race assembly 29, race first, onto the hub of support assembly 23
8. Install two step-joint sealrings 33 onto the hub
9. Retain the bearing and sealrings with oil-soluble grease
10. Check for race 32, which must be at the front of the forward clutch housing
11. Lubricate the outer sealring on the support assembly
12. Install two 3/8-16 x 6-inch headless guide screws J-24315-1 into the transmission housing

JOB SHEET #19

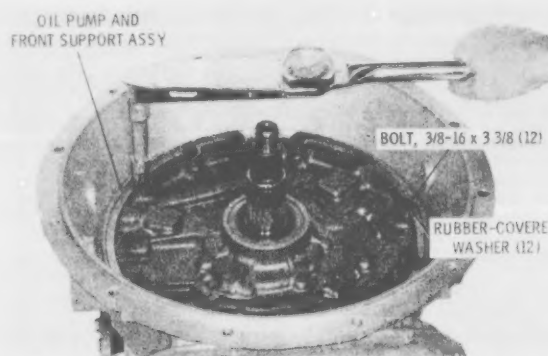
13. Attach front support lifter J-24473 to the converter ground sleeve (Figure 31)

FIGURE 31



14. Align all holes in the front support with the corresponding holes in the transmission housing
15. Index two of these holes to corresponding holes containing the two guide bolts and install the front support
16. Install ten of the twelve 3/8-16 x 3 3/8-inch bolts and rubber-covered washers (Figure 32)

FIGURE 32



17. Remove the two guide bolts and install the two remaining support bolts

(NOTE: Do not tighten the bolts in sequence.)

JOB SHEET #19

18. Maintain an even pull on the outer perimeter of the support by tightening the first two bolts 180° apart to 15 lb ft torque
 19. Move approximately 90° around the bolt circle and repeat the operation
 20. Tighten the remaining opposite pairs of bolts
 21. Repeat the entire process, tightening all twelve bolts to 24-32 lb ft torque
- X. Stop at this point and have your instructor check and initial your procedure and safe practice

INSTRUCTOR CHECK: Procedure ☐ Safety ☐ Initials ☐

- Y. Install the low shift and control valve bodies with the following procedure:

1. Install the governor check ball into the deep pocket end of the governor pressure recess (Figure 33)

FIGURE 33



2. Secure the range selector valve
3. Position the control valve assembly (as reassembled in a previous job sheet) so that the actuator pin enters the housing bore (Figure 33)

JOB SHEET #19

4. Install the control valve body and retain it with seventeen 1/4-20 x 2 1/4-inch bolts and one 1/4-20 x 2 3/4-inch (2 1/4 in later models) bolt

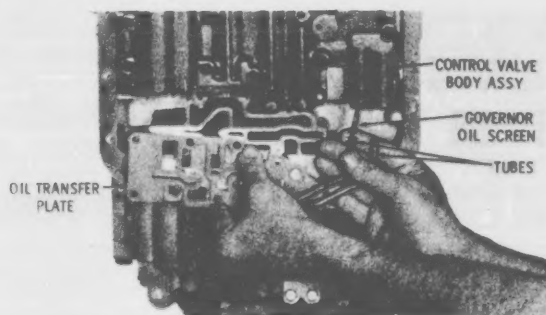
(NOTE: Do not tighten these bolts at this time.)

5. Leave the bolts sufficiently loose to move the valve body for engagement of the selector valve and the installation of the bracketed jumper tubes (used on current models)

6. If the governor oil screen was not discarded during disassembly, discard it (Figure 34)

(NOTE: Later models discontinued the use of the governor oil screen.)

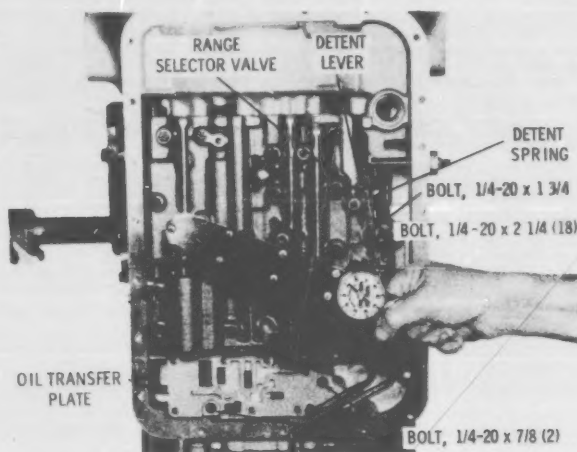
FIGURE 34



JOB SHEET #19

7. Retain the oil thrust plate with two 1/4-20 x 7/8-inch bolts (Figure 35)

FIGURE 35



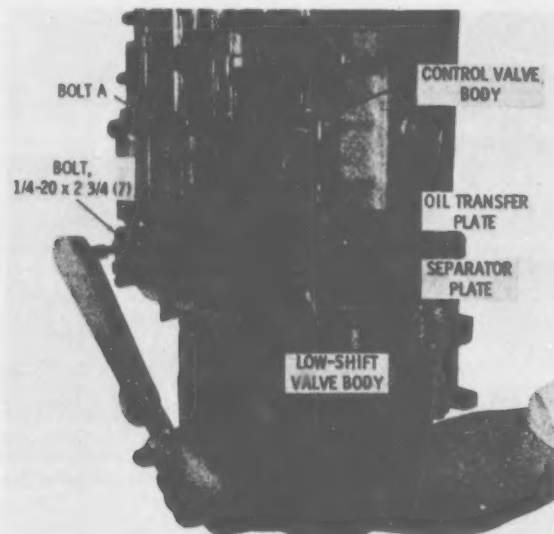
8. Temporarily install seven 1/4-20 x 2 1/2-inch bolts to align the transfer plate
9. Tighten the two 1/4-20 x 7/8-inch bolts to 9-11 lb ft torque, and remove the seven temporarily installed bolts
10. Engage the groove in the range selector valve with the pin on the detent lever (Figure 35)
11. Position the detent spring to engage a notch in the detent lever and install one 1/4-20 x 1 3/4-inch bolt
12. Tighten the bolt to 9-11 lb ft torque

(NOTE: If the jumper tubes have bolt brackets, proceed with the following step.)

JOB SHEET #19

13. Install the separator plate and low shift valve (as reassembled in a previous job sheet) onto the oil transfer plate (Figure 36)

FIGURE 36



14. Install the seven 1/4-20 x 2 3/4-inch bolts to retain the low shift valve, but do not tighten the bolts at this time

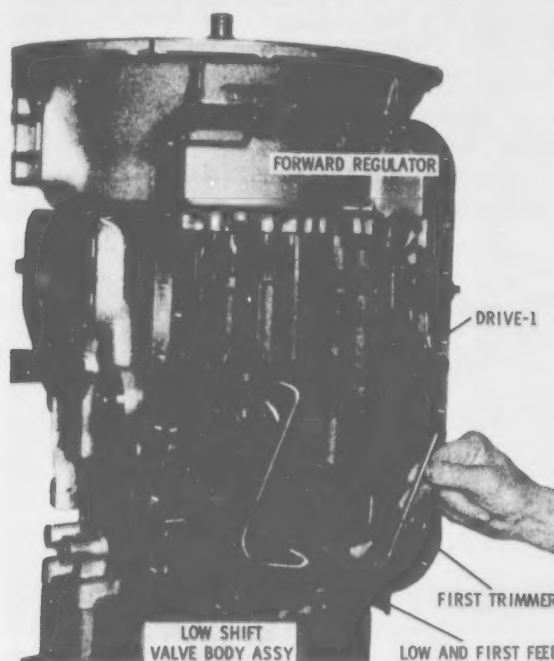
(NOTE: The jumper tubes shown in Figure 37 and described in item 15 below, were used on earlier models; current models use jumper tubes with bolt brackets permanently attached and are described in items 16 through 21 that follow.)

JOB SHEET #19

15. Install the valve jumper tubes in the following sequence by inserting the tube ends into the bores in the valve bodies; drive-1, forward regulator, first trimmer, and low and first feed tube (Figure 37)

(NOTE: The forward regulator tube is not required after serial number 47284; be sure each tube is seated in its bore because failure to seat the tubes properly will cause interference.)

FIGURE 37



16. Place each of the bracketed jumper tubes in their proper positions, inserting the tubes into their respective bores
17. Locate the brackets on the tubes for their particular valve body retaining bolts
18. Mark the bolts and remove the tubes and their corresponding bolts
19. Install the tubes in the same sequence listed in item 15 above
20. Be sure the tubes are properly seated in their respective bores
21. Install the bracket retaining bolts, but do not tighten

JOB SHEET #19

22. Working from the center outward, tighten the seventeen 1/4-20 x 2 1/4-inch control valve body bolts (Figure 35), and one 1/4-20 x 2 3/4-inch (2 1/4 on later models) bolts to 9-11 lb ft torque

23. Tighten the seven low shift valve body bolts to 9-11 lb ft torque

(NOTE: Refer to the service manual for installation of control valve body and tube adapter for Allison models 640 and 643.)

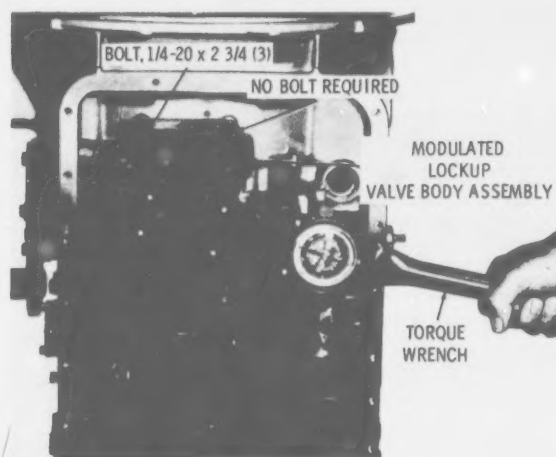
- Z. Stop at this point and have your instructor check and initial your procedure and safe practice

INSTRUCTOR CHECK: Procedure ☐ Safety ☐ Initials ☐

- AA. Install the modulated lockup valve body with the following procedure:

1. Install the modulated lockup valve body assembly (as reassembled in a previous job sheet)
2. Install four 1/4-20 x 2 3/4-inch bolts to retain the valve body (Figure 38)

FIGURE 38



3. Tighten bolts to 9-11 lb ft torque

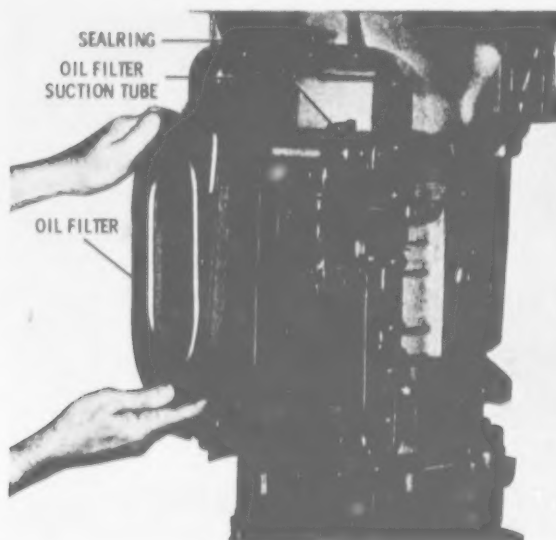
(NOTE: This procedure may be disregarded if the modulated lockup valve body is not used.)

JOB SHEET #19

BB. Install the oil filter with the following procedure

1. Install the oil filter tube into the oil filter (Figure 39)

FIGURE 39



2. Install the sealing onto the upper end of the tube

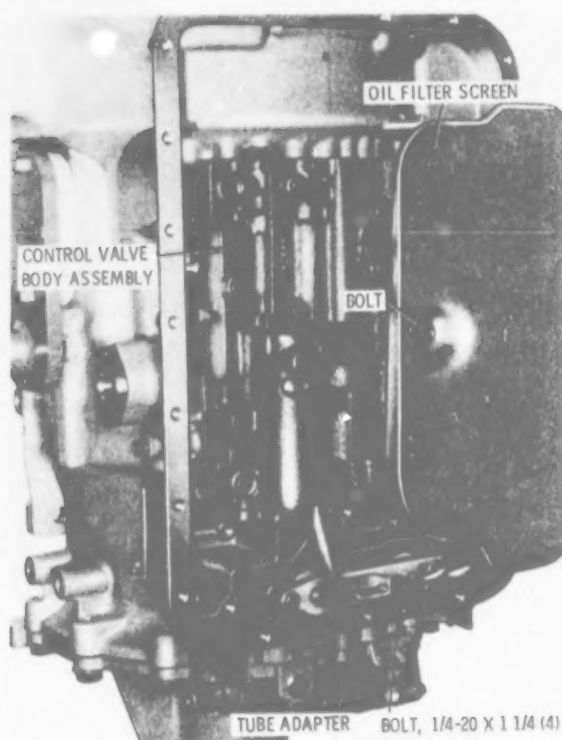
(CAUTION: When installing the oil filter, oil filter tube, and sealing, care must be exercised to prevent twisting the tube or filter in any way that might pinch, cut, or deform the sealing; an air-tight seal must be maintained to enable the oil pump to draw oil from the sump free of entrained air.)

3. Apply oil-soluble grease to both the sealing and its bore in the transmission housing

JOB SHEET #19

4. Install the filter assembly and retain it with one bolt (Figure 40)

FIGURE 40

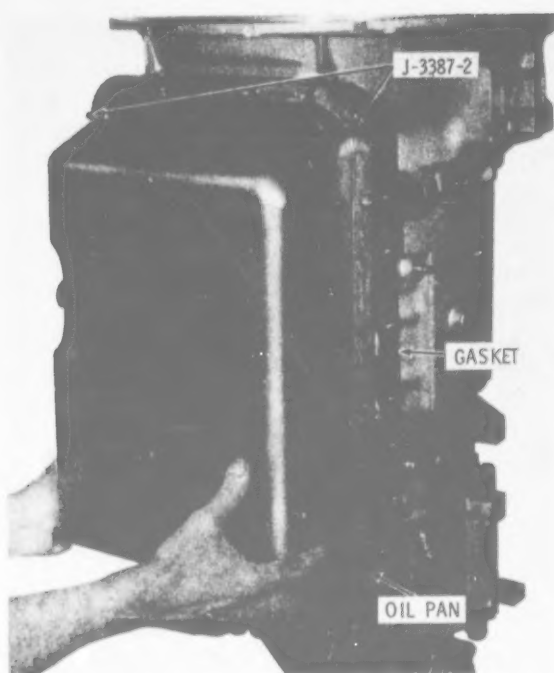


5. Tighten the bolt to 10-15 lb ft torque
- CC. Install the oil pan with the following procedure:
1. Install two 5/16-18 x 3-inch headless guide screws J-3387-2 into the transmission housing

JOB SHEET #19

2. Install the oil pan gasket (Figure 41)

FIGURE 41



3. Install the oil pan and retain it with twenty-one washer-head screws
 4. Remove the two guide bolts for installation of last two screws
 5. Tighten the screws to 10-13 lb ft torque
 6. Allow the gasket to set, then apply 5 lb ft torque to each washer-head screw to ensure a proper seal
- DD. Stop at this point and have your instructor check and initial your procedure and safe practice

INSTRUCTOR CHECK: Procedure ☐ Safety ☐ Initials ☐

JOB SHEET #19

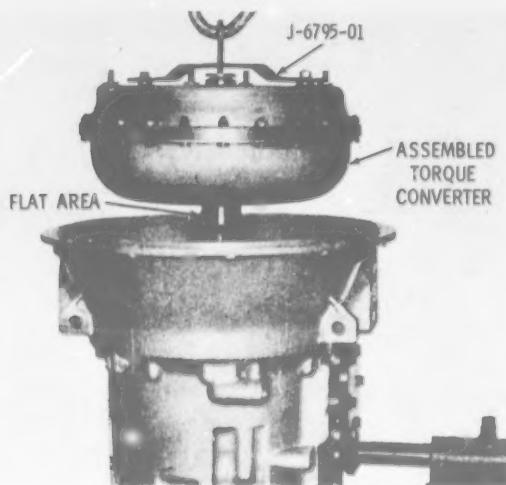
EE. Install the torque converter assembly with the following procedure:

1. Attach torque converter lifter J-6795-1 to the torque converter assembly (as reassembled in a previous job sheet)

(NOTE: After Allison serial number 49489, check to ensure that sealring 35 is lubricated with oil-soluble grease and installed into its groove in pump hub 36 before installing the torque converter assembly; refer to parts list and exploded view in Job Sheet #5 for parts identification.)

2. Suspend the torque converter assembly on a hoist (Figure 42)

FIGURE 42



3. Install the assembly onto the transmission while rotating it to engage the flats on the pump hub with the flats in the transmission oil pump
4. Make sure the splines of the turbine hub, within the converter, engage the splines of the turbine shaft

JOB SHEET #19

5. When the converter assembly is seated, measure the distance from the transmission mounting flange to the converter cover (Figure 43)

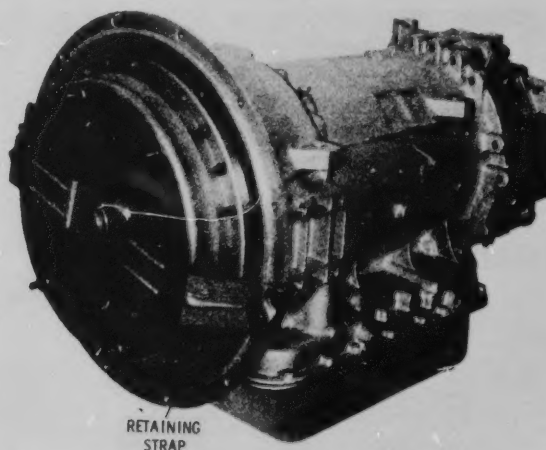
(NOTE: This distance should be approximately 9/16 inch; if the measurement is significantly greater than 9/16 inch, raise the converter assembly slightly, rotate it to align the pump hub flats, and reseal it.)

FIGURE 43



6. Remove lifter J-6795-1, and install a retaining strap to prevent the torque converter assembly from moving (Figure 44)
7. Keep this strap in place until ready to install the transmission into the vehicle

FIGURE 44



JOB SHEET #19

FF. Stop at this point and have your instructor check and initial your procedure and safe practice

INSTRUCTOR CHECK: Procedure ☐ Safety ☐ Initials ☐

GG. Install output components with the following procedure:

1. Install governor drive gear, slot first, onto the output shaft assembly (Figure 45)

FIGURE 45



2. Engage the slot in the drive gear with the protruding pin on the output shaft
3. Install speedometer drive gear 2 and sleeve spacer 3 onto the output shaft

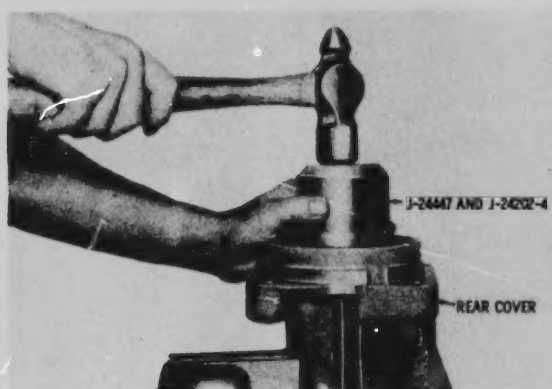
(NOTE: Refer to parts list and exploded view for parts identification.)

4. Place ball bearing 16 into the rear cover

JOB SHEET #19

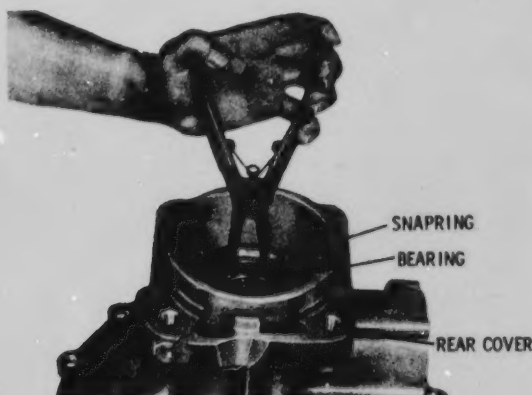
5. Using rear bearing installer, install the bearing until it seats firmly against the snapping in the rear cover (Figure 46)

FIGURE 46



6. Secure the bearing with a beveled snapping (Figure 47)

FIGURE 47

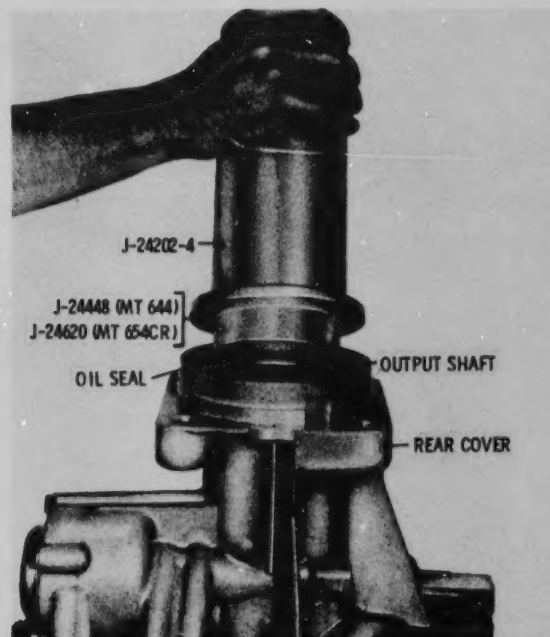


7. Be sure the beveled side of the snapping faces the rear of the transmission, and the snapping is fully expanded into the groove of the housing
8. Apply a nonhardening sealer (Perfect Sealer No. 4 or equivalent) onto the outer surface of the rear oil seal
9. Place the seal on oil seal installer J-24448, sealing lip away from installer

JOB SHEET #19

10. Insert the seal installer and the seal into the rear cover and drive the seal into the bore until its rearward surface is 1.03 to 1.07 inch below the rear face of the cover assembly (Figure 48)

FIGURE 48

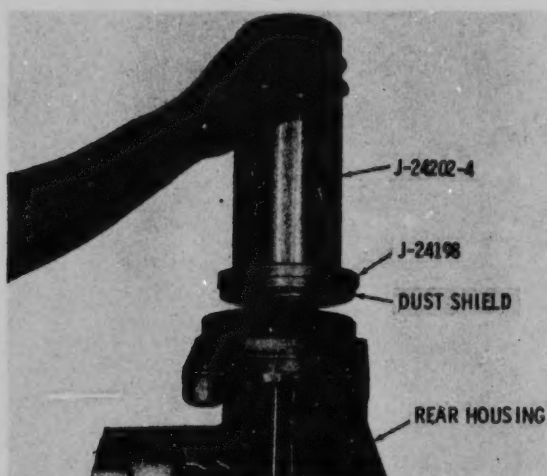


11. Make sure the installer seats against the rear cover hub; this indicates the seal is properly positioned
12. Lubricate and pack the seal with a high-temperature grease that conforms to MIL-G-3545A

JOB SHEET #19

13. Place a dust shield onto dust shield installer J-24198, concave side first (Figure 49)

FIGURE 49



14. Drive the seal into the rear cover until it is flush with, to 0.040 inch below, the rear face of the rear cover assembly; the installer should seat on cover hub

HH. Stop at this point and have your instructor check and initial your procedure and safe practice

INSTRUCTOR CHECK: Procedure Safety Initials

II. Install the governor with the following procedure:

1. Install the governor assembly, gasket, and cover (Figure 19)
2. Retain these components with four 5/16-18 x 9/16-inch bolts, and tighten them to 15-20 lb ft torque

JJ. Make a final inspection to ensure that all subassemblies are properly reinstalled and that the transmission is ready to be reinstalled in the vehicle

KK. Stop at this point and have your instructor check and initial your procedure and safe practice

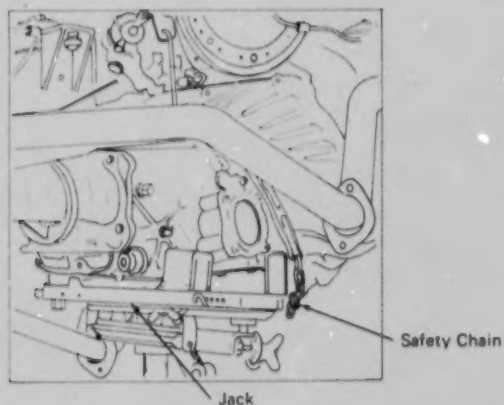
INSTRUCTOR CHECK: Procedure ☐ Safety ☐ Initials ☐

AUTOMATIC TRANSMISSIONS UNIT V

JOB SHEET #20--INSTALL AN AUTOMATIC TRANSMISSION

- I. Tools and materials
 - A. Basic hand tools
 - B. Transmission jack
 - C. Floor jack
 - D. Wooden blocks
 - E. Jack stands
 - F. Hoist
 - G. Drop light
 - H. Creeper
 - I. Shop towels
 - J. Appropriate service manual
 - K. Safety glasses
- II. Procedure
 - A. Remove ground cable from battery if not already removed
 - B. Tighten the converter drain plug and plug in oil pan to specification
 - C. Place transmission on the jack and secure the transmission to the jack with a chain (Figure 1)

FIGURE 1



JOB SHEET #20

- D. Slide transmission under vehicle and align into position
- E. Move the converter and transmission assembly forward into position
(CAUTION: Use care not to damage the flywheel and the converter pilot.)
- F. Rotate the converter until the studs are in alignment with the holes in the flywheel
- G. Move transmission and converter against the flywheel
(NOTE: The converter must rest squarely against the flywheel; this assures that the converter pilot is not binding in the engine crankshaft.)
- H. Install and tighten the converter-housing-to-engine bolts to specification
- I. Tighten converter-to-flywheel studs to specification
- J. Lower transmission to engine mounts and tighten mounts to specification
- K. Remove the safety chain from around the transmission and remove transmission jack
- L. Connect speedometer cable to the transmission
- M. Connect the oil cooler lines to the correct connection
- N. Connect the vacuum lines to the vacuum diaphragm
- O. Connect the downshift rod to the transmission downshift lever
- P. Install the drive shift as marked in removal
- Q. Remove any jack stands (if used) and lower the vehicle
- R. Fill transmission to correct level with the specified fluid
- S. Connect the ground cable to battery
- T. Start the engine and shift transmission through all ranges, then recheck the fluid level
- U. Release the parking brack and remove wooden block from behind wheels
- V. Stop at this point and have your instructor check and initial your procedure and safe practice

INSTRUCTOR CHECK: Procedure ☐ Safety ☐ Initials ☐

**AUTOMATIC TRANSMISSIONS
UNIT V****JOB SHEET #21-TEST AN AUTOMATIC TRANSMISSION**

- I. Tools and materials
 - A. Basic hand tools
 - B. Torque wrench
 - C. Oil pressure gauges (high pressure)
 - D. Clean shop towels
 - E. Vacuum gauge
 - F. Air hoses
 - G. Air nozzle
 - H. Converter leak detector
 - I. Appropriate service manual
 - J. Safety glasses
- II. Procedure
 - A. Check fluid level
 - 1. Bring fluid to operating temperature
 - 2. Place transmission in park
 - 3. Operate engine at idle RPM
 - 4. Apply parking brake
 - 5. Fluid level should be between the Add and Full marks
 - B. Check transmission for fluid leakage
 - 1. Check the speedometer cable connection at the transmission
 - 2. Check leakage at oil pan gasket
 - 3. Check the fluid filler tube connection at the transmission case or pan
 - 4. Check the fluid lines and fittings between the transmission and the cooler
 - 5. Check for leakage at the downshift control lever shaft or the manual lever shaft seals
 - 6. Check for leakage at the converter

JOB SHEET #21

C. Check engine idle speed

1. If the idle speed is too low the engine will run roughly
2. If idle speed is too high the vehicle will try to creep

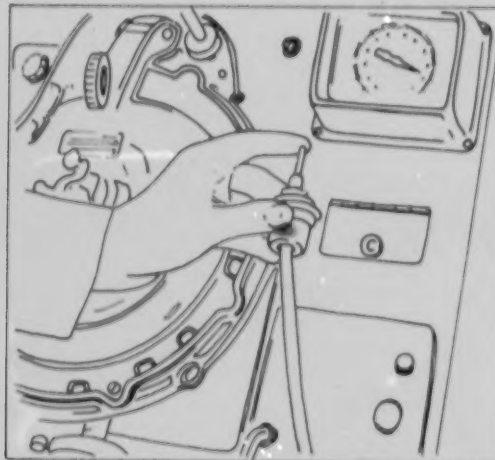
D. Check vacuum pressure

1. Engine vacuum test
2. Remote vacuum test

(NOTE: Check with manufacturer's specification on the transmission being worked on as to what method to use.)

E. Make vacuum diaphragm test for leakage (Figure 1)

FIGURE 1



(NOTE: Check with manufacturer's specification for correct amount for vacuum.)

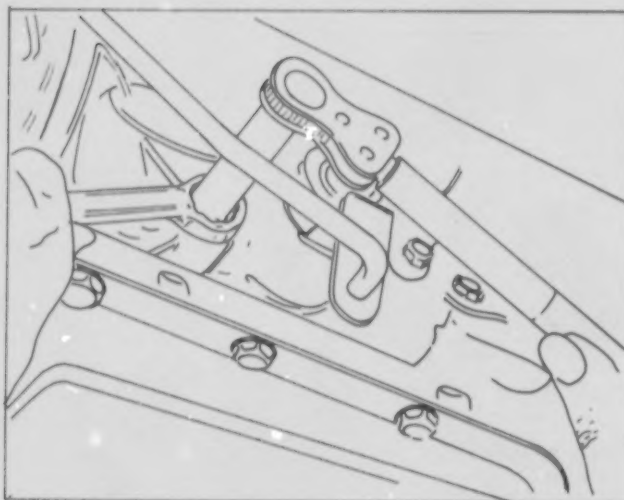
F. Perform the stall test

1. Start the engine and bring transmission fluid to operating temperature
2. Apply parking brake and service brakes

JOB SHEET #21

3. Place transmission in drive
 4. Operate engine at full throttle
 5. If engine does not reach the recommended RPM that is given in specification, it is an indication the clutch or bands are slipping
- G. Check governor operation, and check with manufacturer's specification for correct procedure
- H. Adjust intermediate band (Figure 2)
1. Loosen lock nut several turns
 2. Using a special torque wrench, tighten adjusting screw until torque wrench clicks
- (NOTE: Check with manufacturer's specification on what torque to adjust band on transmission being repaired.)
3. Back off adjusting screw exactly 1 3/4 turns
 4. Hold adjusting screw from turning and tighten lock nut

FIGURE 2



JOB SHEET #21

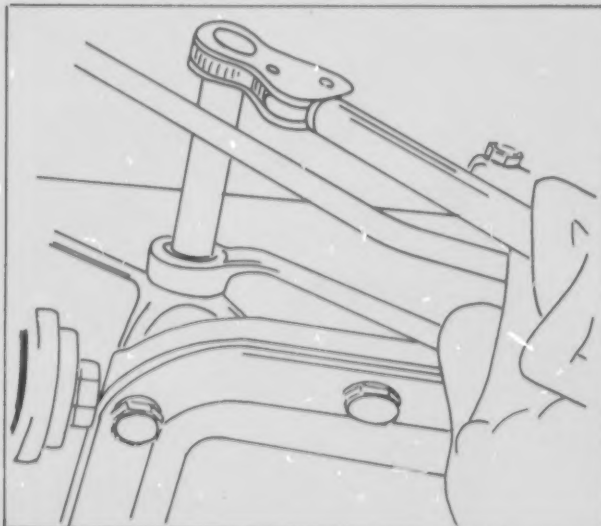
I. Adjust low-reverse band (Figure 3)

1. Loosen lock nut several turns
2. Tighten adjusting screw until pre-set torque wrench clicks

(NOTE: Check with manufacturer's specification on what torque to adjust band on transmission being repaired.)

3. Back off adjusting screw exactly 3 full turns
4. Hold adjusting screw from turning and tighten lock nut

FIGURE 3



- J. Adjust the manual linkage
- K. Adjust throttle and downshift linkage
- L. Stop at this point and have your instructor check and initial your procedure and safe practice

INSTRUCTOR CHECK: Procedure ☐ Safety ☐ Initials ☐

AUTOMATIC TRANSMISSIONS UNIT V

JOB SHEET #22--MAKE SHIFT SPEED ADJUSTMENTS ON AN AUTOMATIC TRANSMISSION

- I. Tools and materials
 - A. Appropriate service manual
 - B. Manufacturer's shift point chart or table
 - C. Test tachometer
 - D. Basic shop tools
 - E. Special adjusting tools as required
 - F. Clean shop towels
 - G. Pencil and paper
 - H. Accurate instruments for checking temperatures, pressures, and vacuums

- II. Procedure

(NOTE: The following procedure and illustrations are adapted from materials published by Detroit Diesel Allison, © General Motors Corporation, and are reprinted with permission; this procedure may be modified by your instructor to facilitate available equipment.)

- A. Make the following checks before adjusting shift points:
 - 1. Warm-up the transmission or test stand setup to normal operating temperature (160° to 220°F) for the road test
 - 2. Check the engine no-load governor setting, and adjust if required, to confirm to the transmission's engine speed requirements
 - 3. Check the engine for satisfactory performance before making shift point adjustments
 - 4. Check the throttle linkage that controls the modulator valve mechanical actuator on the diesel-engine transmission
 - 5. Check vacuum lines for condition and proper routing to vacuum modulator used on most gasoline-engine transmissions
 - 6. Check the shift selector linkage for proper range selection
 - 7. Provide accurate instrumentation required for observing speeds, temperatures, pressures, vacuum, etc.

(NOTE: Transmission shift points cannot be satisfactorily adjusted if the transmission has the wrong governor installed; check transmission serial number with manufacturer's parts list for the governor if there is any doubt.)

JOB SHEET #22

B. Make shift speed adjustments with the road test method by using the following procedure:

1. Before the road test, determine the vehicle tachometer error with a test tachometer, and make corrections for error

2. Note the no-load governed speed of the engine

(NOTE: This is the base speed from which checks and adjustments are made.)

3. Subtract 200 rpm from the governed speed recorded, and record the remainder as the desired speed for all automatic upshifts, except the 1-2 shift of the MT 640, 643, and the 2-3 shift of the MT 650 and 653; the latter two shifts should occur at no-load governed speed, less 600 rpm

4. Drive the vehicle and check the engine speed, at full throttle, at which each upshift occurs

(NOTE: Each upshift should occur at the speeds determined in step 3.)

5. If an upshift speed does not reach that specified, the shift point may be raised by adjusting (increasing) the spring force on the 1-2, 2-3, 3-4, or 4-5 shift signal valves

6. If the upshift speed exceeds the specified rpm, or if upshift does not occur at all, the spring force must be reduced

7. Adjust the force on only the springs for valves that do not upshift at the proper speed

(NOTE: If more than one shift signal valve spring requires adjustment in the same direction, it may be necessary to adjust the spring force on the modulator valve in the same direction; if not adjusted, the closed throttle downshifts may be abnormally high or low depending on the direction the shift signal adjusting rings were rotated; if all full throttle upshift points are too low by approximately the same amount, check adjustment on the modulator external linkage.)

C. Make shift speed adjustments using speedometer readings by using the following procedure:

(NOTE: When a tachometer is not available for checking shift points, the vehicle speedometer can be used.)

1. Check the top speed of the vehicle in each hold position and record the top speed for each

(NOTE: This would be first, second, third gears for MT 640 and 643; second, third, and fourth gears for MT 650 and 653; no third-gear hold is available in MT 650 after serial number 13800 or in MT 653.)

JOB SHEET #22

2. For checking the shift points, place the selector at Drive (D) so that all automatic shifts can occur
3. Drive the vehicle at full throttle from a standing start until the 3-4 (MT 640, 643) or 4-5 (MT 650, 653) upshift occurs
4. Record the speed at which each upshift occurs
5. Compare the upshift speeds with the hold speeds recorded earlier
6. Determine adjustment requirements from the following:
 - a) The 2-3 upshift in the MT 640, 643 should occur at approximately two mph below the top speed for second gear
 - b) The 3-4 upshift should occur at approximately two mph below the top speed for third gear
 - c) The 3-4 and 4-5 upshifts for the MT 650, 653 should occur approximately two mph below the top speeds of third and fourth gear, respectively
 - d) The 1-2 (MT 640, 643) and 2-3 (MT 650, 653) upshifts are not to be adjusted relative to hold speeds; instead, the 2-1 downshift (MT 640, 643) or 3-2 downshift (MT 650, 653) should occur, with closed throttle, at 3 to 5 mph
- D. Make shift speed adjustments using the test stand method by using the following procedure:
 1. Check shift point specifications as given in the manufacturer's service manual
 2. Make all determinations from output shaft speed instead of engine governed speed
 3. Check individual output shaft speed ranges for each shift
 4. Make shift speed adjustments as outlined in the road test method
- E. Stop at this point and have your instructor check and initial your procedure and safe practice

INSTRUCTOR CHECK: Procedure ☐ Safety ☐ Initials ☐

AUTOMATIC TRANSMISSIONS UNIT V

NAME _____

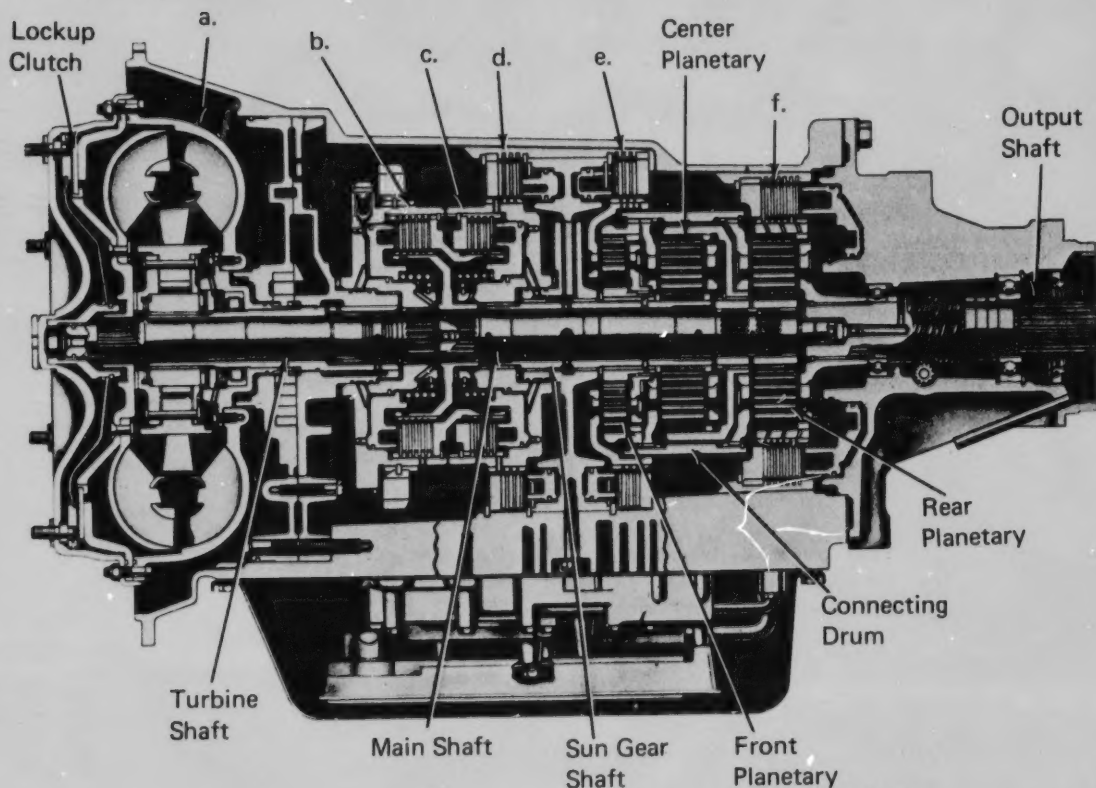
TEST

1. Match the terms on the right with their correct definitions.

- | | |
|--|-----------------------------------|
| <p>_____ a. A device used in automatic transmissions to cushion the shock of clutch and servo actions</p> | <p>1. Shift valve</p> |
| <p>_____ b. A transmission in which gear ratios are changed automatically</p> | <p>2. Power shift</p> |
| <p>_____ c. In an automatic transmission, a hydraulically controlled brake band installed around a metal clutch drum, used to stop or permit drum rotation</p> | <p>3. Kickdown</p> |
| <p>_____ d. A device used in certain automatic transmissions to control gear shifting in relation to vehicle speed</p> | <p>4. Viscosity</p> |
| <p>_____ e. A system in an automatic transmission which produces a downshift when the accelerator is pushed down to the floorboard</p> | <p>5. Planetary gear system</p> |
| <p>_____ f. A clutch which has more than one friction disc; usually there are several driving discs and several driven discs, alternately placed</p> | <p>6. Transmission oil cooler</p> |
| <p>_____ g. A valve that opens to release oil from a line when the oil pressure attains specified maximum limits</p> | <p>7. One-way clutch</p> |
| <p>_____ h. A device in a hydraulic system that converts hydraulic pressure into mechanical movement; it consists of a piston which moves in a cylinder as hydraulic pressure acts on it</p> | <p>8. Wet-disc clutch</p> |
| <p>_____ i. A valve that moves to produce the shifts from one gear ratio to another</p> | <p>9. Multiple-disc clutch</p> |
| <p>_____ j. A clutch in which power can be transmitted in one direction but not in the other</p> | <p>10. Automatic transmission</p> |
| | <p>11. Vacuum modulator</p> |
| | <p>12. Band</p> |
| | <p>13. Governor</p> |
| | <p>14. Accumulator</p> |
| | <p>15. Pressure regulator</p> |
| | <p>16. Servo</p> |

- _____ k. A small radiator, mounted separately or as part of the engine radiator, to cool the transmission lubricating oil
- _____ l. A clutch in which the friction disc is operated in a bath of oil
- _____ m. The resistance of a liquid to flow
- _____ n. A device in automatic transmissions that modulates, or changes, the mainline hydraulic pressure to meet changing engine loads
- _____ o. A gear-set consisting of a central sun gear surrounded by two or more planet pinions which are, in turn, meshed with a ring gear; used in overdrives and automatic transmissions
- _____ p. A transmission designed to provide high speed by the use of hydraulic actuated clutches operated manually

2. Identify the major parts of the automatic transmission in the following illustration:



3. Arrange in order oil pump and pressure regulator valve operation by placing the correct sequence number in the appropriate blank.

- _____ a. As pressure is built up, the valve rises and one band will uncover the passage leading to the return line, and this prevents the pressure from getting too high
- _____ b. While engine is running, the pump directs the oil to the pressure regulator valve, then the oil comes in around the lands of the spool
- _____ c. As the oil in the teeth of the gears is carried around to other side of crescent, the teeth come together, pressure is created, and the oil is forced out the pressure cavity

- _____ d. The valve is usually of the spool type and, when there is no pressure on valve, the spring pushes the valve to the bottom of its bore
 - _____ e. As the teeth of the two gears move apart oil is drawn in through an oil cavity
 - _____ f. The oil pump can create low flow at low speed and high flow at high speed, so a pressure regulating valve is used to keep pump from building to high flow
 - _____ g. The oil pump is of the gear type, and the crescent is part of the pump housing
 - _____ h. As the oil flows through the pressure line, a small amount flows through an orifice under the valve
 - _____ i. When the inner gear is turned by the converter hub the outer gear also turns
 - _____ j. The hub of the converter pump fits into notches of the oil pump and driving oil pump when engine is running
4. Select true statements concerning low range, high range, and reverse range functions in an automatic transmission by placing an "X" in the appropriate blanks.

(NOTE: For a statement to be true, all parts of the statement must be true.)

_____ a. Low range

- 1) The engine turns the torque converter, which turns the transmission pump and input shaft
- 2) Low band is applied either manually or by hydraulic pressure
- 3) When the low band is applied the clutch drum and low sun gear are held stationary
- 4) The input sun gear is turning in the same rotation as the engine
- 5) The input sun gear is in mesh with the long pinion gears, which are in mesh with the short pinion gears
- 6) As the short pinion gears walk around the ring gear, the output shaft is connected to the planetary-pinion carrier, which is rotating with the planet gears

_____ b. High range

- 1) Engine turns torque converter, which turns oil pump and input shaft
- 2) The low band is released in high range
- 3) The forward clutch is applied which locks the sun gear to the input shaft
- 4) The whole planetary gear system turns as a unit

_____ c. Reverse range

- 1) Engine supplies power to the torque converter, which turns oil pump and input shaft
- 2) The low band and forward clutch are released
- 3) The reverse clutch is applied either manually or by hydraulic pressure
- 4) The reverse ring gear is held stationary, and the sun gear turns the planet gears in the opposite directions
- 5) Since the planet carrier is attached to the planet gears, it is turning the same direction as the planet gears
- 6) The output shaft is attached to the planet carrier which is turning in reverse

5. Complete a list of statements concerning the characteristics of automatic transmission fluid.

a. Automatic transmission fluid has several additives, such as:

1. _____ index improver
2. Oxidation and corrosion inhibitors
3. Extreme-pressure and _____ agents
4. Detergents
5. Dispersants
6. _____ modifiers
7. _____ point depressants
8. Fluidity modifiers

b. The _____ is added to fluid so it will not be confused with any other lubricants

c. Do not use a fluid that is not recommended by manufacturer because it could cause _____

6. Arrange in order the procedure for properly checking automatic transmission fluid by placing the correct sequence number in the appropriate blank.

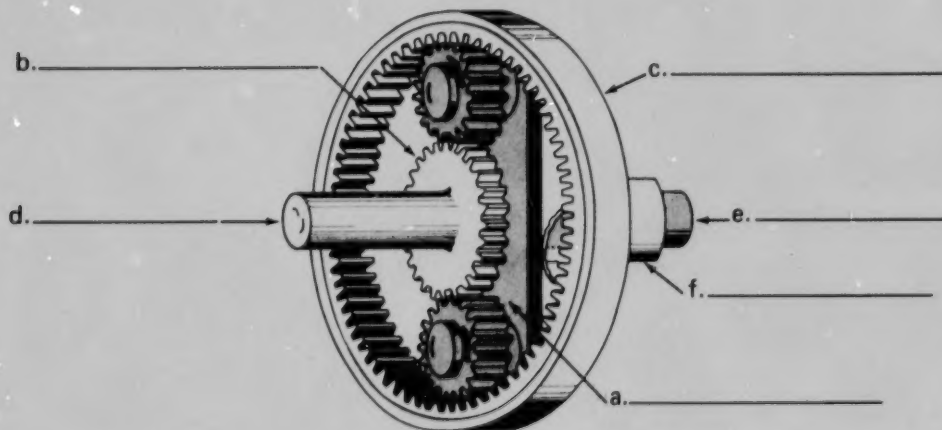
- _____ a. Leave engine idling and shift transmission into recommended position
- _____ b. Operate engine until transmission fluid is at normal operating temperature
- _____ c. Pull dipstick and check if level is between arrows or Full and Add marks; adjust fluid level as necessary
- _____ d. Clean all dirt from around dipstick and cap

- _____ e. Block wheels and apply parking brake
- _____ f. Pull out and wipe dipstick; reinsert until cap bottoms on filler tube
- _____ g. Shift transmission through all ranges at idle speed

7. Match in-vehicle transmission tests with their functions.

- | | |
|---|------------------------|
| _____ a. Warms up transmission fluid to operating temperature, and indicates overall characteristics of transmission operation | 1. Fluid pressure test |
| _____ b. Indicates the condition of torque converter operation and strength of hydraulic system | 2. Road test |
| _____ c. Tests each hydraulic circuit and compares it with manufacturer's specifications to detect general problems in hydraulic components | 3. Air pressure test |
| _____ d. Tests each hydraulic component individually for pressure leaks | 4. Stall test |

8. Identify the parts of the planetary gear system in the following illustration.



9. Complete the following statements concerning the planetary-gear system.

- a. A planetary gear system can act as a _____ increaser and a torque reducer
- b. The planetary gear system also can act as a _____ reducer and a torque increaser

- c. The planetary system can also act as a means to _____ flow of power
- d. To get different speeds and different torques and reverse is made possible by applying the _____ rotation to different gears and _____ one of the other two gears stationary
10. Match speed, torque, and directional functions of an automatic transmission with ways they are accomplished.
- | | |
|---|------------------------------------|
| _____ a. If the sun gear is held stationary and the planet-pinion carrier turns, there is a speed increase at the ring gear | 1. Speed increased--torque reduced |
| _____ b. If the ring gear is held stationary and the sun gear turns, the planet-pinion carrier turns in the same direction as the sun gear but at a slower speed | 2. Reverse |
| _____ c. If the ring gear is held stationary and the planet-pinion carrier turns, there is a speed increase at the sun gear | 3. Direct drive |
| _____ d. If the planet-pinion carrier is held stationary and the sun gear turns, the planet-pinion acts as an idler gear and turns the ring gear in opposite rotation of sun gear | 4. Speed reduced--torque increased |
| _____ e. If the sun gear is held stationary and the ring gear turns, there is a speed reduction in the rotation of the planet-pinion carrier | |
| _____ f. If any two of the three members are locked together, the whole planetary gear system is locked out and the input and output shaft turn at the same speed | |
| _____ g. If the planet-pinion carrier is held stationary and the ring gear turns, the planet pinion acts as an idler gear and turns sun gear in opposite rotation of ring gear | |
11. Complete the following list of tools and equipment required for automatic transmission overhaul.
- 1500-pound capacity work table
 - Special tools as recommended by manufacturer in service manual
 - Common mechanic's tools and shop equipment
 - Snapping pliers
 - _____

- 3) 3-leg lifting sling of 1/2 ton capacity with 90° angle attaching plates
 - 4) 1/2 ton capacity hoist
 - 5) Container of volatile mineral spirits for cleaning parts
 - 6) Torque wrenches: 100-inch pound, 100-foot pound, and 1000-foot pound
 - 7) Hot plate or heating equipment for heating bearings or other interference-fit parts to aid assembly
 - 8) _____
 - 9) Boxes, receptacles for parts
 - 10) Supply of wood blocks
 - 11) Oil-soluble grease
 - 12) Nonhardening sealer, Peratex No. 2 or equivalent
 - 13) _____
 - 14) Soft honing stone
12. Name three parts normally replaced at each transmission overhaul.
- a. _____
 - b. _____
 - c. _____
13. Select true statements concerning important elements of cleaning and inspection by placing an "X" in the appropriate blanks.
- _____ a. All parts must be clean to permit effective inspection
 - _____ b. All the metallic parts of the transmission, except bearings and friction-faced clutch plates, should be thoroughly cleaned with volatile mineral spirits or by steam cleaning
 - _____ c. Parts should be dried with clean rags
 - _____ d. Steam-cleaned parts should be oiled immediately after drying
 - _____ e. Oil passages should be cleaned by working a piece of soft wire back and forth through the passages and flushing with mineral spirits, then drying with compressed air
 - _____ f. Examine all parts, especially oil passages, after cleaning to make certain they are entirely clean

14. Complete the following statements concerning special considerations for bearing inspection and handling.

- a. Inspect bearings for roughness of rotation; replace bearing if rotation is still rough after _____
- b. Inspect bearings for scored, pitted, scratched, cracked, or chipped races, and for excessive wear of rollers or balls; if any one of these defects is found, _____
- c. Inspect bearing housing and shaft for grooved, burred or galled conditions that would indicate the bearing had been turning _____
 - d. Do not remove _____ from new bearings until ready to install them
- e. Do not remove _____ in which new bearings are packed
- f. Do not lay bearings on a dirty bench; place them _____
- g. If assembly is not to be _____, wrap or cover the exposed bearings with clean paper or lint-free cloth to keep dust out

15. Match other transmission components with their inspection requirements

- | | |
|---|-----------------------------------|
| _____ a. Inspect bores for wear, scratches, grooves, and dirt | 1. Oil seals and gaskets |
| _____ b. Inspect for obstructions | 2. Seal contact surfaces |
| _____ c. Inspect for nicks, burrs, scratches, and foreign matter | 3. Mounting faces |
| _____ d. Inspect for damaged threads | 4. Splined parts |
| _____ e. Inspect for scores, burrs, roundness, sharp edges, and evidence of overheating | 5. Cast parts, machined surfaces |
| _____ f. Inspect for distortion, scores, burrs, and wear | 6. Bushings |
| _____ g. Inspect sealrings for cuts and hardness; replace all composition gaskets | 7. Balls in clutch housing |
| _____ h. Inspect for scuffed, nicked, burred, or broken teeth; inspect thrust face for scores, scratches, and burrs | 8. Thrust washers |
| _____ i. Inspect for stripped, twisted, chipped, or burred splines | 9. Swaged, interference-fit parts |
| _____ j. Inspect for nicks, distortion, and excessive wear | 10. Oil passages |
| _____ k. Inspect for signs of overheating, permanent set, or wear due to rubbing against adjacent parts | 11. Clutch plates |

- _____ l. Inspect friction-faced steel plates for burrs, embedded metal particles, severely pitted faces, excessive wear, cone, cracks, distortion, and damaged spline teeth; inspect steel plates for burrs, scoring, excessive wear, cone distortion, embedded metal, galling, cracks, breaks, and damaged tangs
 - _____ m. Inspect for looseness due to relative motion
 - _____ n. Inspect for restrictions to free movement
 - _____ o. Inspect for roughness, scoring, pitting, or wear that will either permit oil leakage or cause damage to the seal
12. Springs
13. Gears
14. Threaded openings
15. Snaprings
16. Arrange in order the make-ready procedures for removing or installing an automatic transmission by placing the correct sequence number in the appropriate blank.
- _____ a. Drain the oil from the transmission before removing the transmission from the vehicle
 - _____ b. Install a retaining strap to hold the converter in place as soon as the transmission is clear of its mountings
 - _____ c. Clean the exterior of the transmission
 - _____ d. At reinstallation, all items should be reconnected; a transmission jack is convenient to raise the transmission into mounting position
 - _____ e. Fill the transmission with oil
 - _____ f. Road test the transmission after installation
 - _____ g. Make sure that all linkages, controls, cooler lines, modular actuator cable, temperature connection, input and output couplings, and mounting bolts are disconnected before transmission removal, also the oil filler tube and other equipment such as attached parking brake handle
 - _____ h. Place oil lines safely out of the way of damage and cover all oil line openings to keep dirt out
 - _____ i. Place jack or hoist sling relative to transmission center of gravity
17. List three general rules for determining whether to reuse or replace a part.
- a. _____
 - _____
 - b. _____
 - _____
 - c. _____
 - _____

18. Demonstrate the ability to:

- a. Remove an automatic transmission from a vehicle.
- b. Disassemble an automatic transmission into subassemblies.
- c. Check end play on a torque converter assembly.
- d. Disassemble, clean, and inspect a torque converter assembly.
- e. Rebuild a stator assembly.
- f. Reassemble a torque converter assembly.
- g. Disassemble, clean, inspect, and reassemble a modulated lockup valve assembly.
- h. Disassemble, clean, inspect, and reassemble a low shift valve assembly.
- i. Disassemble, clean, inspect, and reassemble a control valve body assembly.
- j. Disassemble, clean, inspect, and reassemble an oil pump and front support assembly.
- k. Disassemble, clean, inspect, and reassemble a forward clutch and turbine shaft.
- l. Disassemble, clean, inspect, and reassemble a fourth clutch.
- m. Disassemble, clean, inspect, and reassemble a center support assembly.
- n. Disassemble, clean, inspect, and reassemble a gear unit and main shaft assembly.
- o. Disassemble, clean, inspect, and reassemble an output shaft.
- p. Disassemble, clean, inspect, and reassemble a rear cover assembly.
- q. Disassemble, clean, inspect, and reassemble an adapter housing and first clutch piston.
- r. Disassemble, clean, inspect, and reassemble a transmission housing.
- s. Reassemble an automatic transmission.
- t. Install an automatic transmission.
- u. Test an automatic transmission.
- v. Make shift speed adjustments on an automatic transmission.

(NOTE: If these activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

AUTOMATIC TRANSMISSIONS

UNIT V

ANSWERS TO TEST

- | | | | |
|-------|----|----|----|
| 1. a. | 14 | i. | 1 |
| b. | 10 | j. | 7 |
| c. | 12 | k. | 6 |
| d. | 13 | l. | 8 |
| e. | 3 | m. | 4 |
| f. | 9 | n. | 11 |
| g. | 15 | o. | 5 |
| h. | 16 | p. | 2 |

2. a. Torque converter
 b. Forward clutch
 c. Fourth clutch
 d. Third clutch
 e. Second clutch
 f. First clutch

- | | | | |
|-------|----|----|---|
| 3. a. | 10 | f. | 6 |
| b. | 8 | g. | 2 |
| c. | 5 | h. | 9 |
| d. | 7 | i. | 3 |
| e. | 4 | j. | 1 |

4. a, b, c

5. a. 1. Viscosity
 3. Antifoam
 6. Friction
 7. Pour
- b. Red dye
 c. Serious damage to transmission

6. a. 4
 b. 2
 c. 7
 d. 5
 e. 1
 f. 6
 g. 3

7. a. 2
 b. 4
 c. 1
 d. 3

8.
 - a. Planet gears
 - b. Sun gear
 - c. Ring gear
 - d. Shaft to sun gear
 - e. Tube to ring gear
 - f. Shaft to carrier
9.
 - a. Speed
 - b. Speed
 - c. Reverse
 - d. Input, holding
10.

a.	1	e.	4
b.	4	f.	3
c.	1	g.	2
d.	2		
11.
 - c.
 - 2) Micrometer
 - 8) Clean, lint-free shop cloths
 - 13) Crocus cloth
12. Any three of the following:
 - a. Gaskets
 - b. Lockstrips
 - c. Washers or springs damaged by removal
 - d. Oil seals and piston sealrings
13. a, b, d, e, f
14.
 - a. Cleaning and oiling
 - b. Replace the bearings
 - c. In the bore or on the shaft
 - d. The wrapper
 - e. The grease
 - f. On clean, lint-free cloths or paper
 - g. Completed at once
15.

a.	5	e.	6	i.	4	m.	9
b.	10	f.	8	j.	15	n.	7
c.	3	g.	1	k.	12	o.	2
d.	14	h.	13	l.	11		
16.

a.	1	f.	9
b.	5	g.	2
c.	6	h.	3
d.	7	i.	4
e.	8		
17.
 - a. Minor surface irregularities can usually be corrected with a crocus cloth and the part can be reused
 - b. Some nicks, scuffs, and burrs can be corrected with a soft honing stone and the part can be reused
 - c. Parts that cannot be smoothed or corrected with crocus cloth or a soft honing stone or parts that are obviously distorted or excessively worn should be replaced
18. Performance skills evaluated to the satisfaction of the instructor

DRIVE LINES UNIT VI

UNIT OBJECTIVE

After completion of this unit, the student should be able to identify parts of propeller shafts, center bearings, and cross and roller U-joints. The student should also be able to disassemble, inspect, and reassemble a U-joint, troubleshoot other problems with drive lines, and balance a propeller shaft. This knowledge will be evidenced by correctly performing the procedures outlined in the job sheets and by scoring 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms related to drive lines with their correct definitions.
2. List two characteristics of a hotchkiss drive.
3. Identify types of propeller shafts.
4. Identify parts of a propeller shaft with slip yoke.
5. Identify parts of a center bearing.
6. Differentiate between constant velocity and cross and roller U-joints.
7. Identify parts of a cross and roller U-joint.
8. Select points on a drive train to check component angles.
9. Select true statements concerning acceleration-deceleration of propeller shaft with cardon U-joints.
10. Complete a list of problems causing drive line noise or vibration.
11. Demonstrate the ability to:
 - a. Remove and replace a propeller shaft.
 - b. Disassemble, inspect, and reassemble a U-joint with bolted end.
 - c. Remove and replace a cross and roller U-joint.
 - d. Align and time a telescoping drive line.
 - e. Balance a propeller shaft.

DRIVE LINES UNIT VI

SUGGESTED ACTIVITIES

- I. Provide student with objective sheet.
- II. Provide with information and job sheets.
- III. Make transparencies.
- IV. Discuss unit and specific objectives.
- V. Discuss information sheet.
- VI. Demonstrate and discuss the procedures outlined in the job sheets.
- VII. Take students on field trips to shops that build and repair drive lines.
- VIII. Have a representative from a drive line manufacturer talk to the class about modern drive line technology.
- IX. Show film on drive line components.
- X. Give test.

INSTRUCTIONAL MATERIALS

- I. Included in this unit:
 - A. Objective sheet
 - B. Information sheet
 - C. Transparency masters
 1. TM 1--U-Joint Arrangement
 2. TM 2--Hotchkiss Drive
 3. TM 3--Propeller Shaft With Shift Yoke
 4. TM 4--Propeller Shaft--Coupling Shaft and Center Support Bearing
 5. TM 5--Propeller Shaft--Coupling Shaft Without Center Bearing
 6. TM 6--Telescoping Propeller Shaft Components

7. TM 7--Types of U-Joints
8. TM 8--Point on Drive Train to Check Component Angles
9. TM 9--Acceleration-Deceleration in a Cross and Roller Propeller Shaft

D. Job sheets

1. Job Sheet #1--Disassemble, Inspect, and Reassemble a U-joint with Bolted End Caps
2. Job Sheet #2--Remove and Replace a Propeller Shaft
3. Job Sheet #3--Remove and Replace a Cross and Roller U-joint
4. Job Sheet #4--Align and Time a Telescoping Drive Line
5. Job Sheet #5--Balance a Propeller Shaft

E. Test

F. Answers to test

II. References:

- A. *Fundamentals of Service: Power Trains*. Moline, IL 61265: John Deere Service Publications, Dept. F, 1972.
- B. *Truck Talk*. Chicago, IL 60611: International Harvester Co., 1977.
- C. *Eaton Truck Components Drive Line Angles*. Kalamazoo, MI 49007: Eaton Corporation, Transmission Division, 1979.
- D. *Truck Service Section, Diagnosing Drive Train CT 237*. International Harvester Co., 1977.
- E. *Ford Truck Shop Manual Volume One*. Dearborn, MI: Ford Motor Co., 1968.

DRIVE LINES
UNIT VI

INFORMATION SHEET

I. Terms and definitions

- A. Parallel U-joint arrangement--All companion flanges or yokes in the drive line are parallel to each other with working angles of the joints equal and opposite (Transparency 1)
- B. Broken back arrangement--The working angles of the joints are equal, but the yokes are nonparallel (Transparency 1)
- C. Universal joint--A flexible coupling that permits a driving shaft to operate between two power train units that are not in perfect alignment with each other and are subject to movement

(NOTE: When installed on a propeller shaft, the universal joint allows the shaft to rotate through an angle.)

- D. Propeller shaft--Shaft that connects two units of the drive train to propel vehicle
- E. Drive line--Driving connection made up of one or more propeller shafts between two or more units of the drive train
- F. Constant velocity U-joint--Two closely coupled cross and roller U-joints arranged so that their acceleration-deceleration effects cancel each other, resulting in output propeller shaft speed identical to input speed
- G. Slip joint--Variable-length connection at one end of a propeller shaft that allows the shaft to vary in length

(NOTE: The propeller shaft has to vary in length due to movement of drive train components.)

- H. Cardon joint--Cross and roller U-joint

(NOTE: Cardon joint is also called hooke joint.)

- I. Whirl--Propeller shaft runout or unbalance condition causing the shaft to arc similar to the looping action of a rope held at both ends and swung in an arc

(NOTE: Whirl can be caused by turning propeller shaft at too high an R.P.M. for the size of the shaft.)

- J. U-joint timing--Procedure of aligning the yokes of a propeller shaft parallel to each other

(NOTE: U-joint timing is sometimes called phasing.)

INFORMATION SHEET

- K. Center support bearing--A bearing and mount assembly used to support the rear of a drive shaft when two or more drive shafts are used (Transparency 4)

(NOTE: The center support bearing is also called center bearing, midship bearing, or carrier bearing.)

II. Characteristics of a hotchkiss drive (Transparency 2)

- A. Open U-joints
- B. Exposed drive line

(NOTE: Closed or torque-tube drives formerly used on some passenger cars are practically nonexistent now; the open hotchkiss drive is much easier to maintain and repair and improves the operational characteristics of the drive train components.)

III. Types of propeller shafts (Transparencies 3, 4, 5, and 6)

- A. Coupling shaft and center support bearing
- B. Propeller shaft with slip yoke
- C. Coupling shaft without center bearing

(NOTE: The coupling shaft is used between transmission and auxiliary transmission.)

- D. Telescoping propeller shaft

IV. Parts of a propeller shaft with slip yoke (Transparency 3)

- A. Flange yoke
- B. Journal and bearing
- C. Sleeve yoke
- D. Slip stub shaft
- E. Tubing
- F. Stub yoke
- G. End yoke
- H. Slip U-joint
- I. Permanent U-joint

V. Parts of a center bearing (Transparency 4)

- A. Bearing
- B. Rubber support

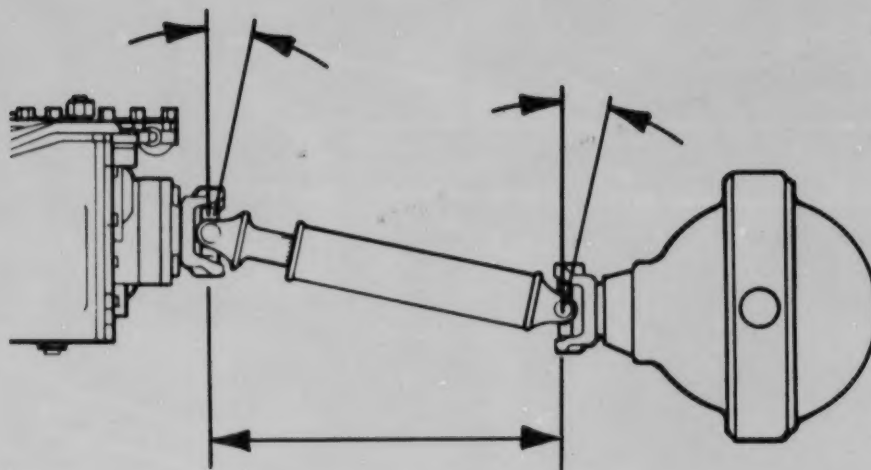
INFORMATION SHEET

- C. Retainer
- D. Support
- VI. Types of U-joints (Transparency 7)
 - A. Constant velocity (cross and roller type)
 - B. Cross and roller (cardon)
- VII. Parts of a cross and roller U-joint (Transparency 7)
 - A. Bearing cap
 - B. Yoke
 - C. Spider (cross)
 - D. Lock plate
- VIII. Points on a drive train to check component angles (Transparency 8)
 - A. Machined pad on rear of transmission
 - B. Coupling drive shaft on clean tubing section
 - C. Front yoke or flange of auxiliary transmission
 - D. Front yoke on forward rear axle
 - E. Interaxle drive line on clean tubing
 - F. Front yoke of rear rear axle
- IX. Acceleration-deceleration of propeller shaft with cardon U-joints
 - A. Input side of U-joint turns at constant r.p.m. (Transparency 9)
 - B. Output of U-joint accelerates and decelerates two times during one revolution of the shaft (Transparency 9)
 - C. The greater the U-joint angle the greater the effect will be
- X. Problems causing drive line noise or vibration
 - A. Out of balance emergency brake drum on rear of transmission or auxiliary
 - B. Lack of lubrication in the U-joints
 - C. Worn U-joint bearings

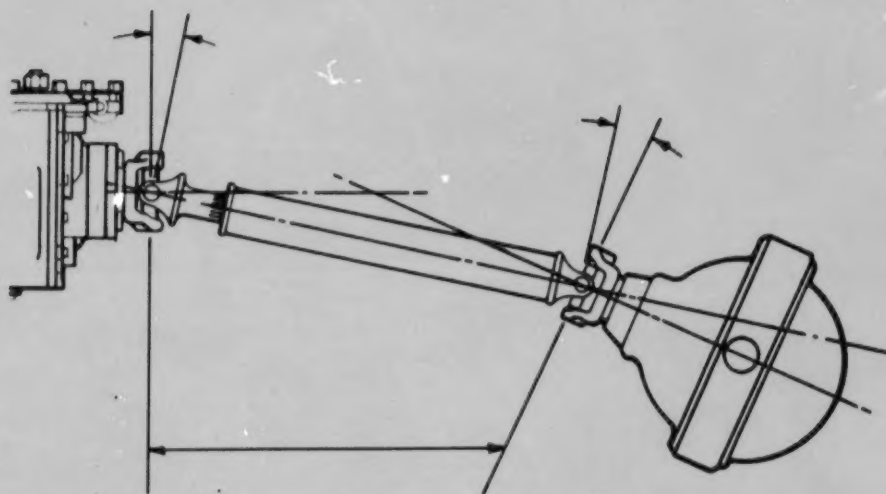
INFORMATION SHEET

- D. Bind in slip yoke
- E. Sprung or damaged drive shaft
- F. Missing balance weight
- G. Drive shaft U-joint out of time
- H. Foreign material on drive shaft
- I. Loose or worn engine mounts
- J. Loose or worn rear suspension
- K. Excessive drive shaft angles

U-Joint Arrangement



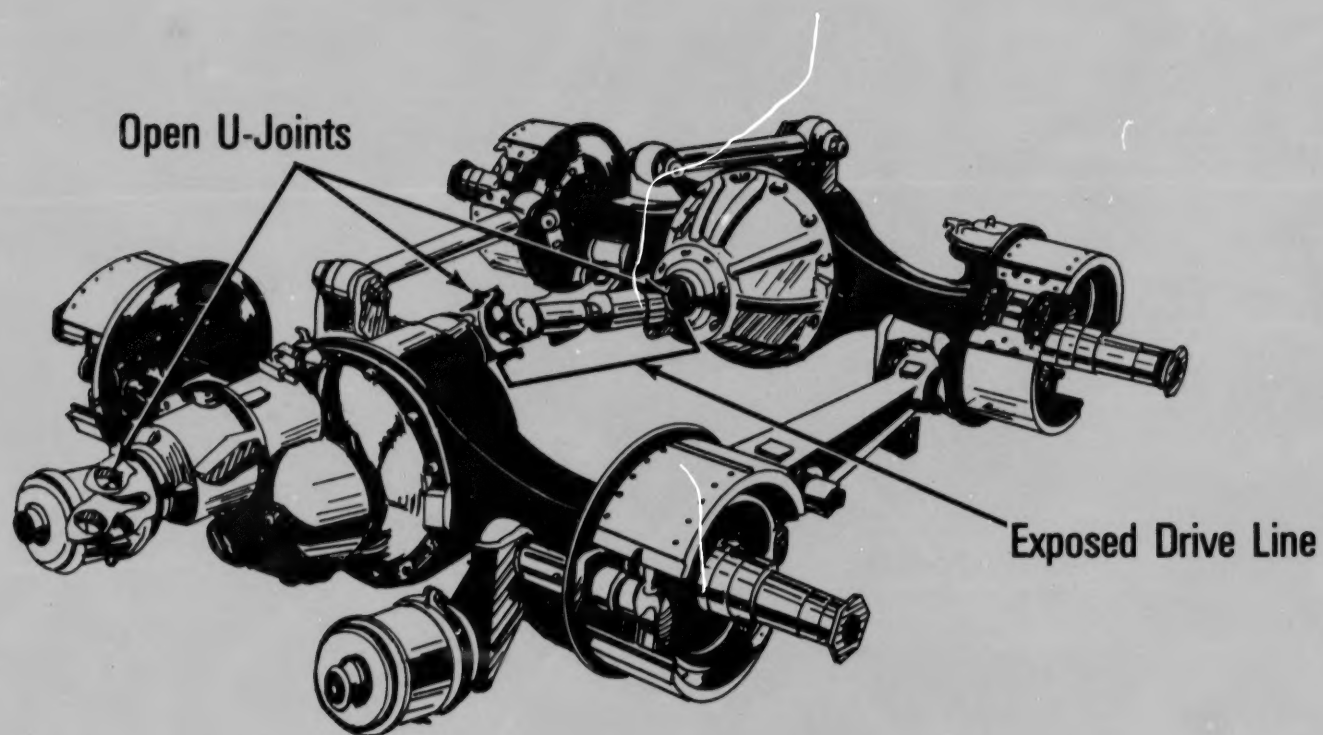
Parallel Arrangement



Broken Back or Nonparallel Arrangement

Courtesy Eaton Corporation

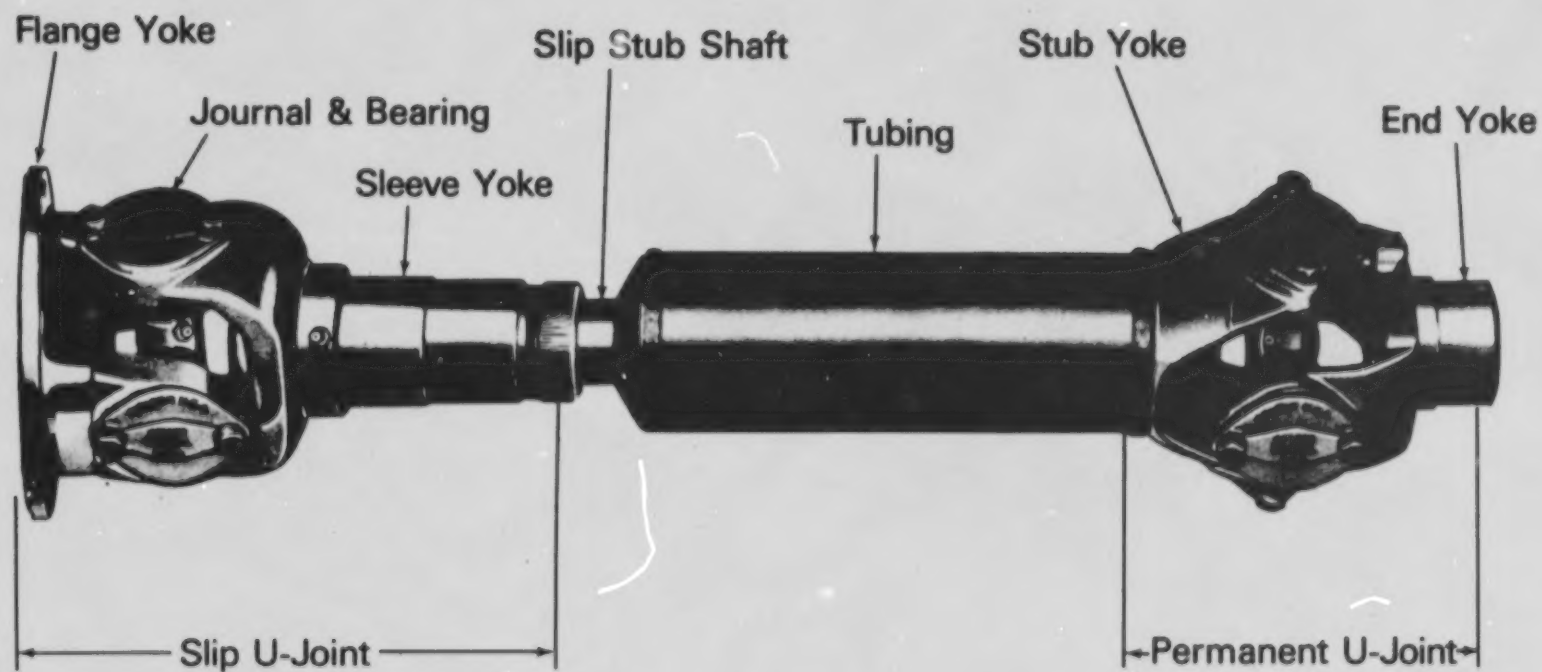
Hotchkiss Drive



515

516

Propeller Shaft with Slip Yoke

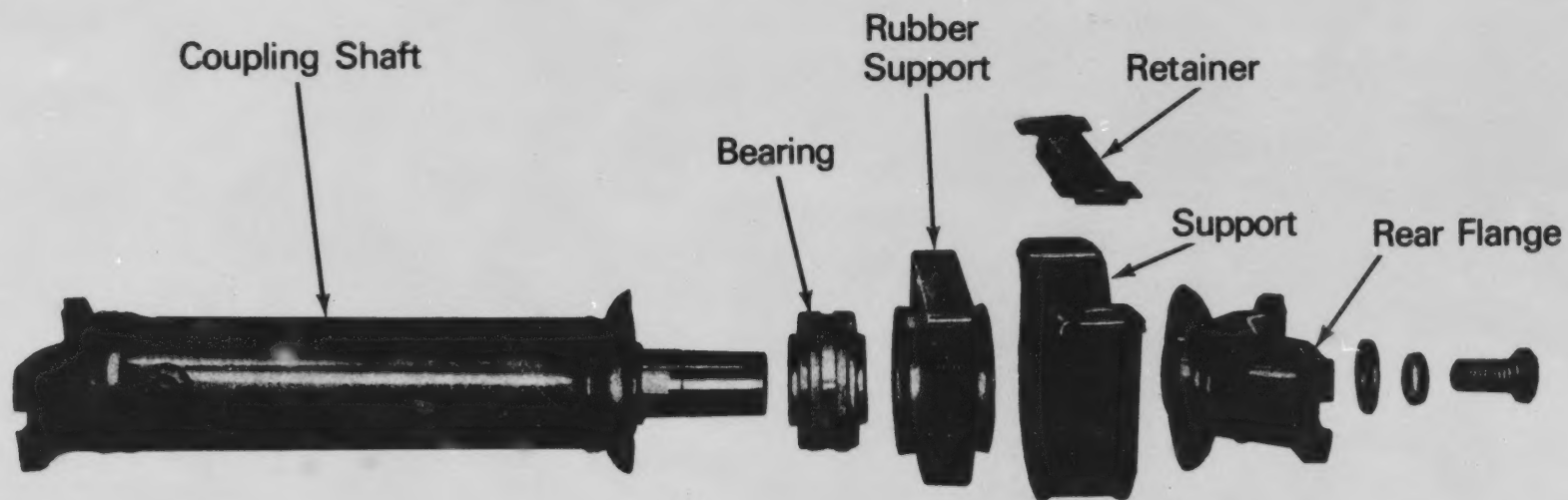


517

Courtesy DEERE & CO., MOLINE, IL

518

Propeller Shaft--Coupling Shaft and Center Support Bearing

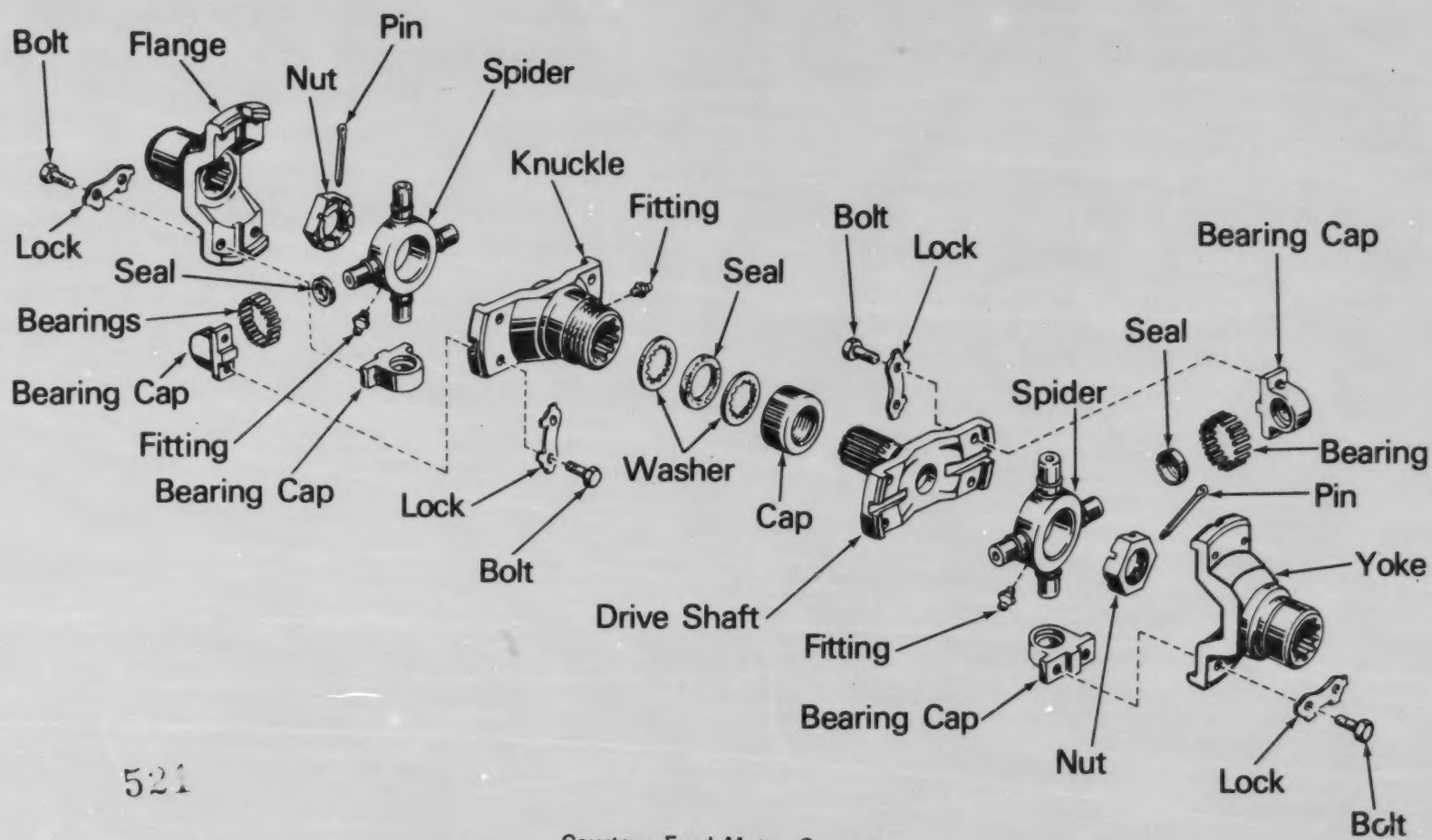


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520

Courtesy Ford Motor Company

Propeller Shaft-Coupling Shaft Without Center Bearing

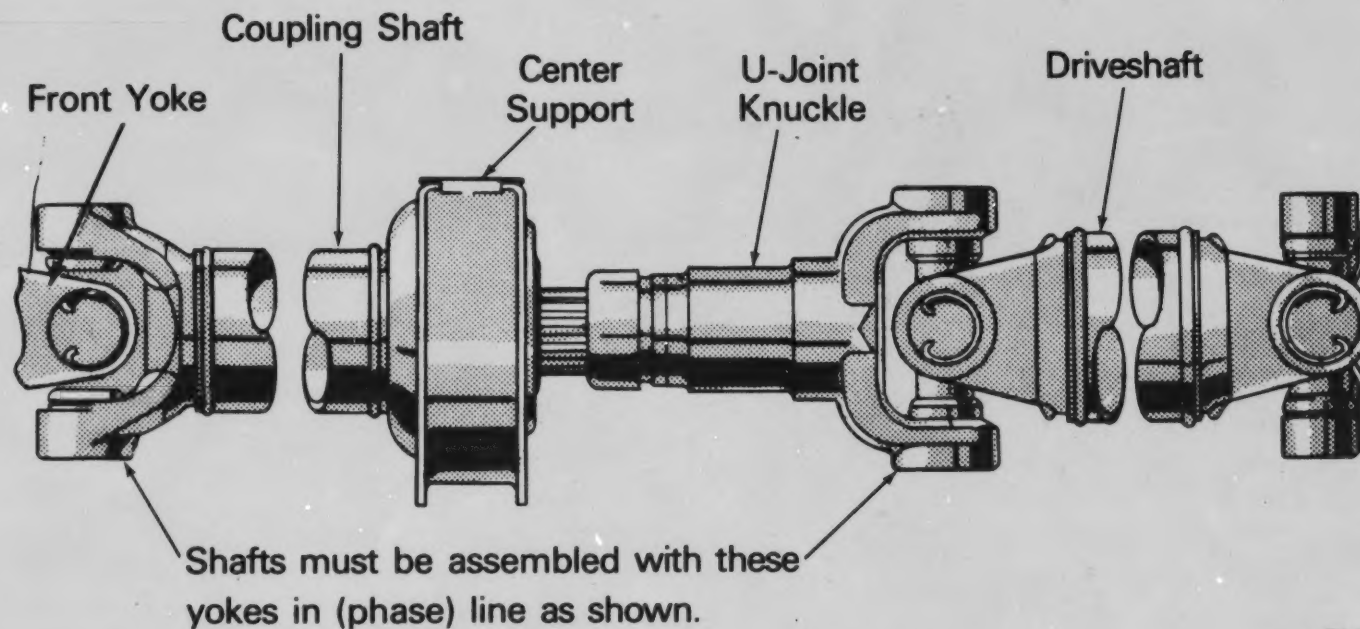


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Courtesy Ford Motor Company

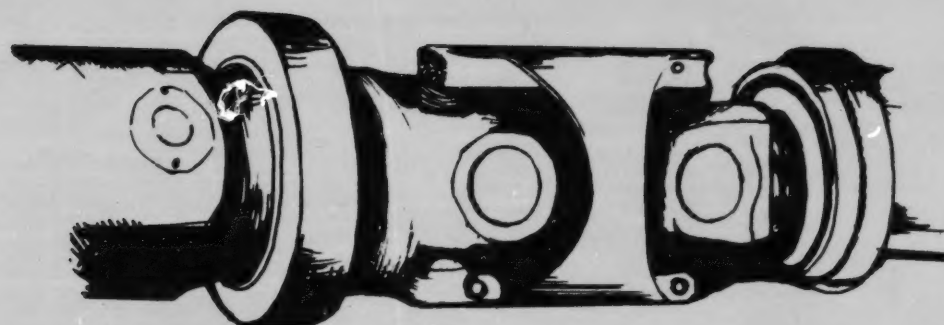
522

Telescoping Propeller Shaft Components

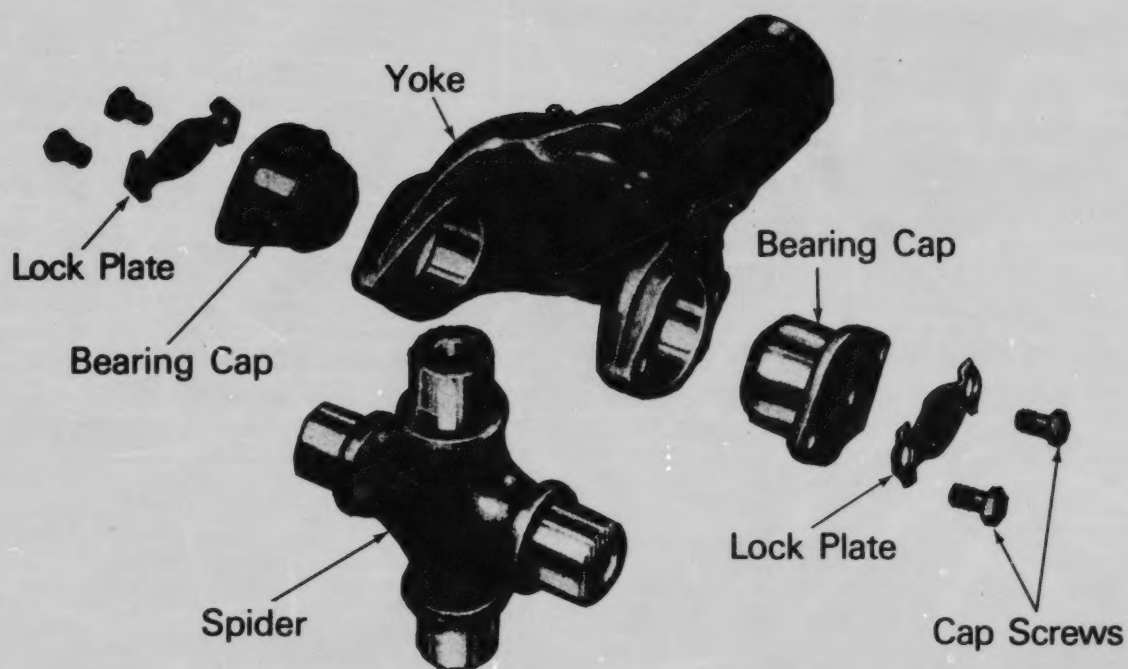


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Types of U-Joints

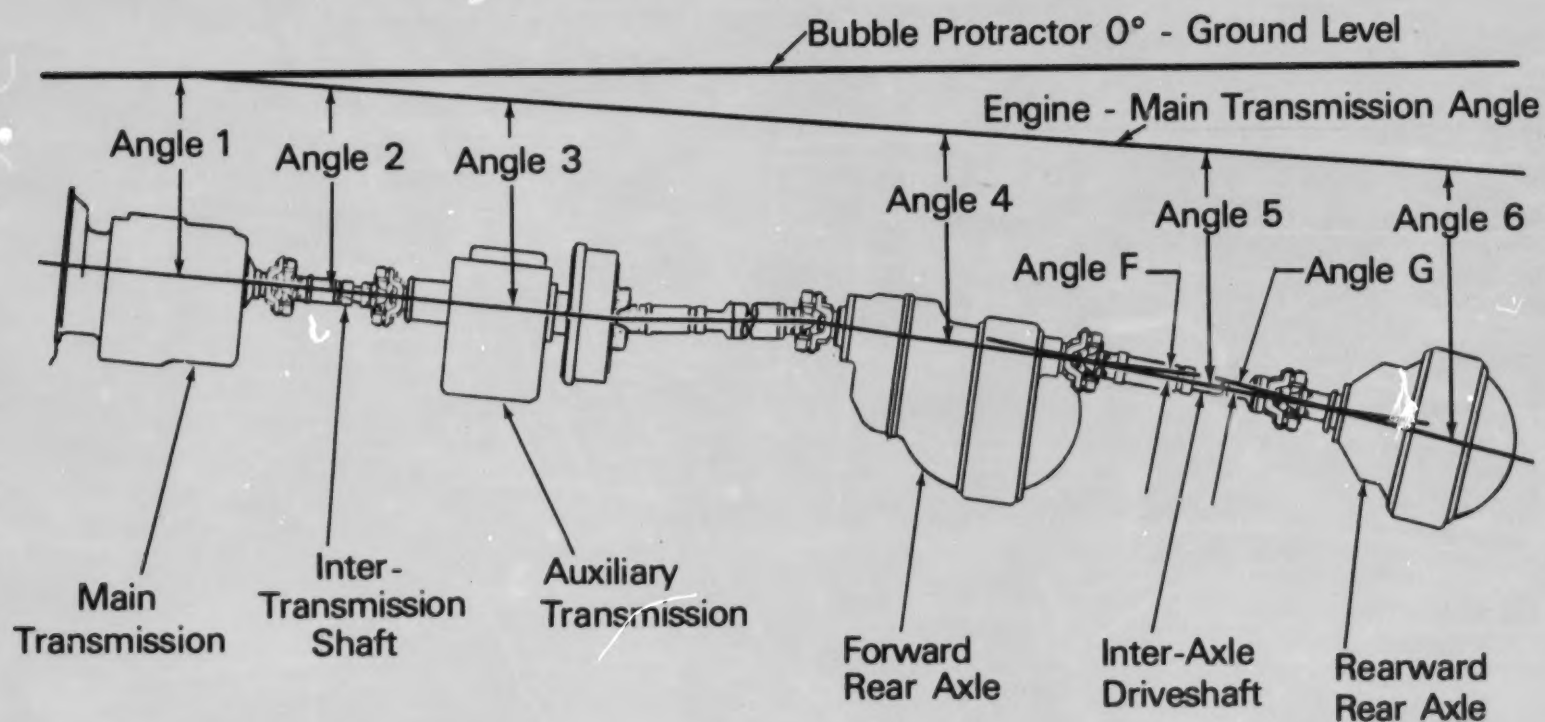


Constant Velocity

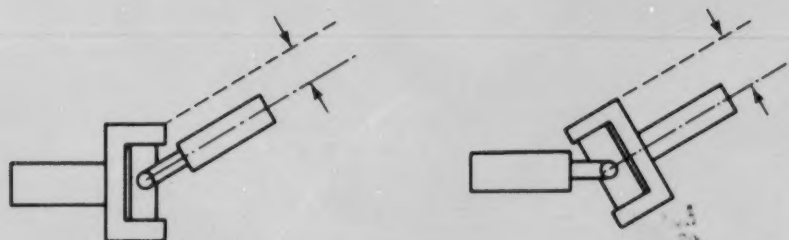


Cross and Roller (Cardan)

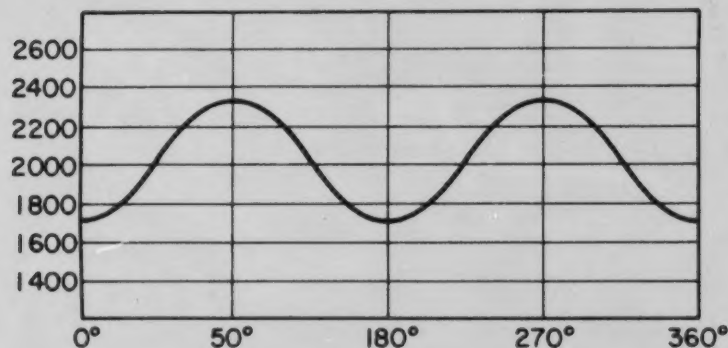
Points on Drive Train to Check Component Angles



Acceleration - Deceleration in a Cross and Roller Propeller Shaft



Turning Radius Changes as Joint Rotates



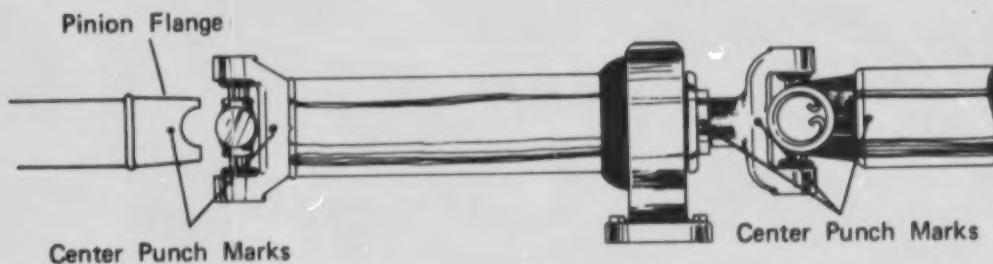
Graph of a Cross and Roller U-Joint Speed Change with the
Joint Operating Through a 30° Angle at 2000 rpm Input.

**DRIVE LINES
UNIT VI****JOB SHEET #1--REMOVE AND REPLACE A PROPELLER SHAFT****I. Tools and equipment**

- A. Floor jack
- B. Jack stands
- C. Basic hand tool set
- D. Soft hammer
- E. Torque wrench and adapter
- F. Creeper
- G. Safety glasses

II. Procedure

- A. Jack up rear of vehicle and place jack stands under frame
- B. Mark all joints and yokes with a center punch to retain balance and phasing (Figure 1)

FIGURE 1

- C. Remove propeller shaft attaching bolts

(NOTE: Study the propeller shaft to determine how it is fastened.)

- D. Remove the center support bearing if a two-piece propeller shaft is used

(NOTE: Check between center support and frame for shims. If shims are used, they must be replaced when propeller shaft is reinstalled.)

JOB SHEET #1

E. Remove propeller shaft from vehicle

(NOTE: Tape U-joint rollers to prevent loss of needle bearings. See Figure 2. The slip yoke should also be protected to prevent damage during removal.)

FIGURE 2



(CAUTION: When removing, replacing, or servicing a propeller shaft, careless handling can damage the shaft and U-joints.)

F. Service propeller shaft

G. Reinstall propeller shaft

1. Place in position and check alignment marks

(NOTE: All mounting surfaces should be clean and free of nicks before assembly.)

2. Position all fasteners correctly and tighten evenly
3. Replace fasteners in center support bearing if used

(NOTE: Replace shims between frame and support if used.)

4. Torque all fasteners to manufacturer's specifications

H. Jack up rear of car and remove jack stands

I. Lower vehicle to floor

DRIVE LINES
UNIT VIJOB SHEET #2--DISASSEMBLE, INSPECT, AND REASSEMBLE
A U-JOINT WITH BOLTED END

I. Tools and materials

- A. Basic hand tool set
- B. Creeper
- C. Shop towels
- D. Cleaning material
- E. Chock blocks
- F. Hydraulic jack
- G. Jack stands
- H. Safety glasses

II. Procedure

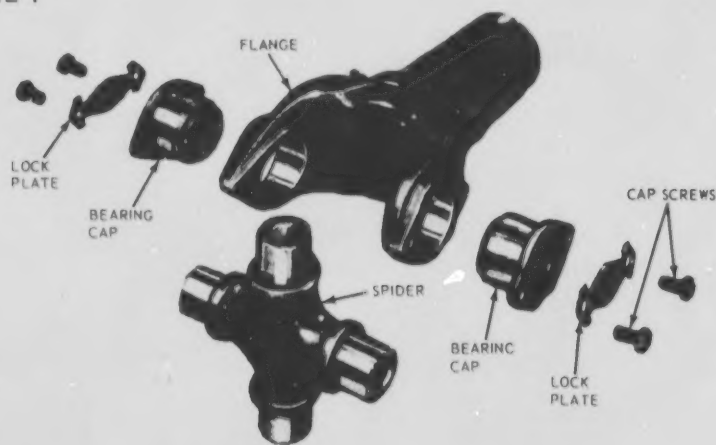
A. Remove propeller shaft with bolted end caps

1. Jack up rear of vehicle if necessary
2. Place jack stands under rear axle or frame

(CAUTION: Wear safety glasses when under vehicle.)

3. Bend tangs of lockplates away from capscrew heads (Figure 1)

FIGURE 1



JOB SHEET #2

4. Remove capscrews and lockplates
5. Remove bearing caps from flange and spider

(NOTE: If caps have to be driven out with a hammer, be careful not to damage flange or prop tube.)

B. Inspect U-joint with bolted ends

1. Clean all U-joint parts
2. Check bearing journals for evidence of wear or heat damage; also check ends of crosses
3. Make sure lubricant passages in cross are clean
4. Check for missing, worn, or damaged needle bearings
5. Apply recommended lubricant to rollers in caps
6. Turn caps on journals to check for wear

(NOTE: If any parts are worn or damaged, replace with new parts.)

C. Install U-joint with bolted ends

1. Position the needle bearing in the bearing caps
2. Place spider in yokes on propeller shaft
3. Install bearing caps through the yokes and onto the spider
4. Install lockplates and capscrews
5. Position spiders through yokes on drive train units
6. Install bearing caps

(NOTE: Take care not to damage bearings when installing caps.)

7. Install lockplates and caps
8. Lubricate both U-joints

DRIVE LINES UNIT VI

JOB SHEET #3--REMOVE AND REPLACE A CROSS AND ROLLER U-JOINT

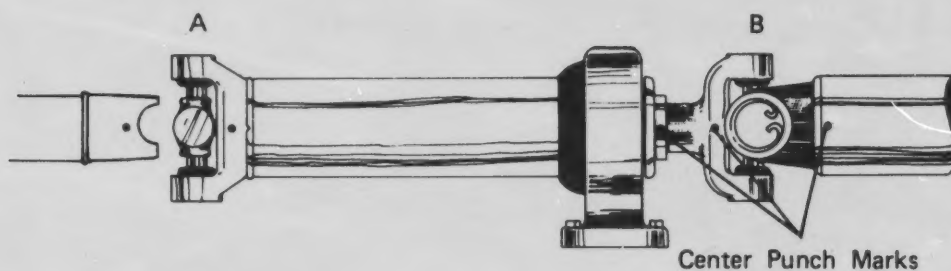
I. Tools and equipment

- A. Basic hand tool set
- B. Soft hammer
- C. Brass punch
- D. Vise
- E. Safety glasses

II. Procedure

- A. Mark all parts with a center punch so the parts may be reassembled in the same positions (Figure 1)

FIGURE 1



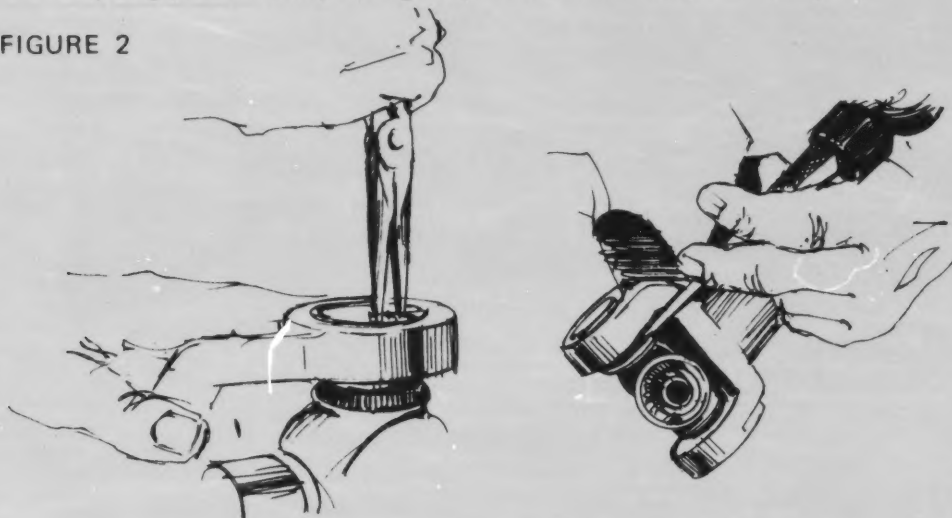
(NOTE: It is very important to align the propeller shafts parts A and B when reassembling the two shafts.)

JOB SHEET #3

- B. Remove snap rings or retainer plates and grease fittings as required (Figure 2)

(CAUTION: If the propeller shaft is held in the vise while removing the snap rings, do not bend, overtighten, or scar the shaft with the vise.)

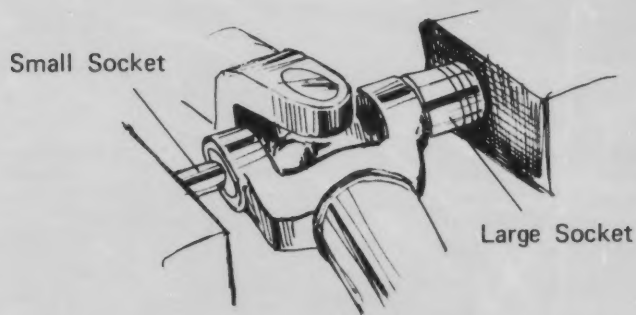
FIGURE 2



- C. Place a small socket against one roller; place a large socket against the yoke on the opposite side (Figure 3)
- D. Place in a vise and close the vise jaws until the roller assembly is pressed out of the yoke (Figure 3)

(CAUTION: Be sure the large socket has enough room to allow the roller to enter without wedging in the socket, and do not use a hammer to install bearings.)

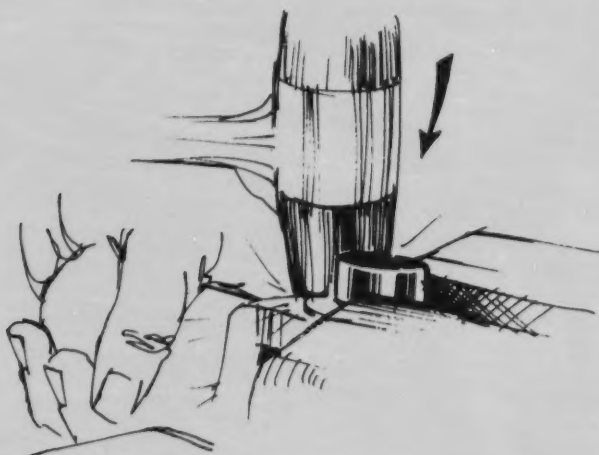
FIGURE 3



JOB SHEET #3

(NOTE: Remove roller with pliers or soft hammer. See Figure 4.)

FIGURE 4



- E. Place small socket on remaining roller; place the large socket against the yoke on the opposite side

(NOTE: Use caution to avoid damaging seal shields.)

- F. Place in a vise and close the vise jaws until the roller assembly is pressed out of the yoke

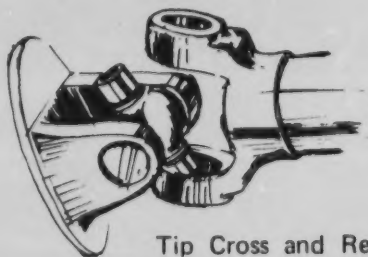
(NOTE: Refer to Figure 3.)

- G. Remove roller with pliers or soft hammer

(NOTE: Refer to Figure 4.)

- H. Remove the cross from the yoke (Figure 5)

FIGURE 5



Tip Cross and Remove from Yoke

JOB SHEET #3

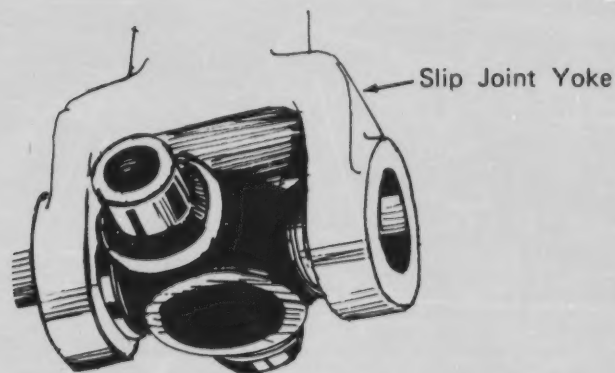
- I. Remove other rollers using the same procedure
- J. Inspect cross trunnions for excessive wear, corrosion, or grooving; check all needle bearings for chipping or breakage

(NOTE: If the components are not worn, they may be correctly lubricated and reused. If there is any sign of wear, install a new U-joint.)

- K. Reassemble the U-joint

- 1. Place the cross in the propeller shaft yoke (Figure 6)

FIGURE 6



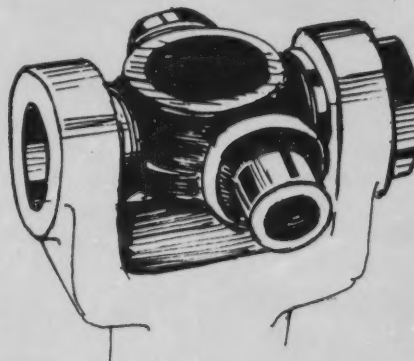
- 2. On U-joint with grease fittings, the fitting should be positioned on the propeller shaft side to allow clearance for lubrication after installation

(NOTE: It provides a welcome service convenience when all grease fittings are in line.)

JOB SHEET #3

2. Slide the cross to one side and start a roller over the cross bearing race (Figure 7)
3. Start the roller in the yoke eye (Figure 7)

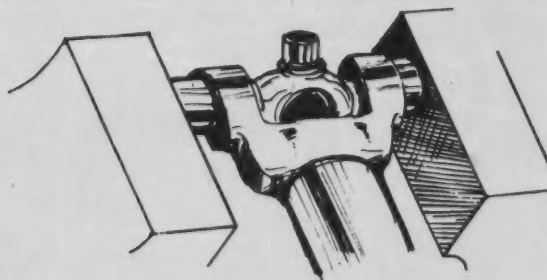
FIGURE 7



4. Place U-joint in a vise and press the roller into the yoke eye (Figure 8)

(NOTE: Be sure to keep the cross in the roller bearings to prevent the bearings from loosening or getting out of their proper position.)

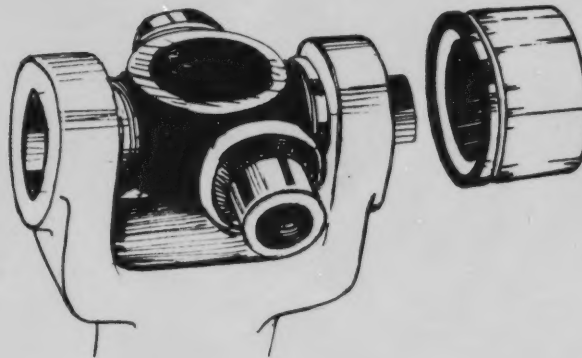
FIGURE 8



JOB SHEET #3

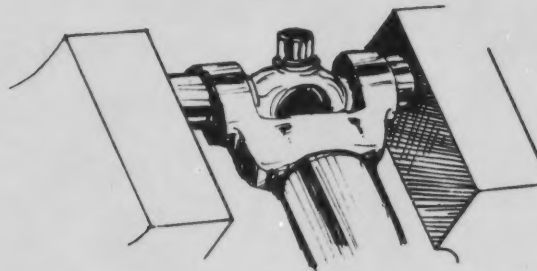
5. Install the snap ring into the roller groove or yoke eye groove according to the type of U-joint
6. Slide the cross slightly out of the roller so that the opposite roller can be started on the cross bearing race (Figure 9)

FIGURE 9



7. Place in a vise and press the roller into the yoke eye sufficiently to install the snap ring (Figure 10)

FIGURE 10



JOB SHEET #3

8. Replace remaining U-joint rollers using the same procedure; install remaining snap rings
9. Strike yoke to seat rollers against the snap rings and to position the cross (Figure 11)

(NOTE: Make sure the U-joint is not binding throughout its range of movement.)

FIGURE 11



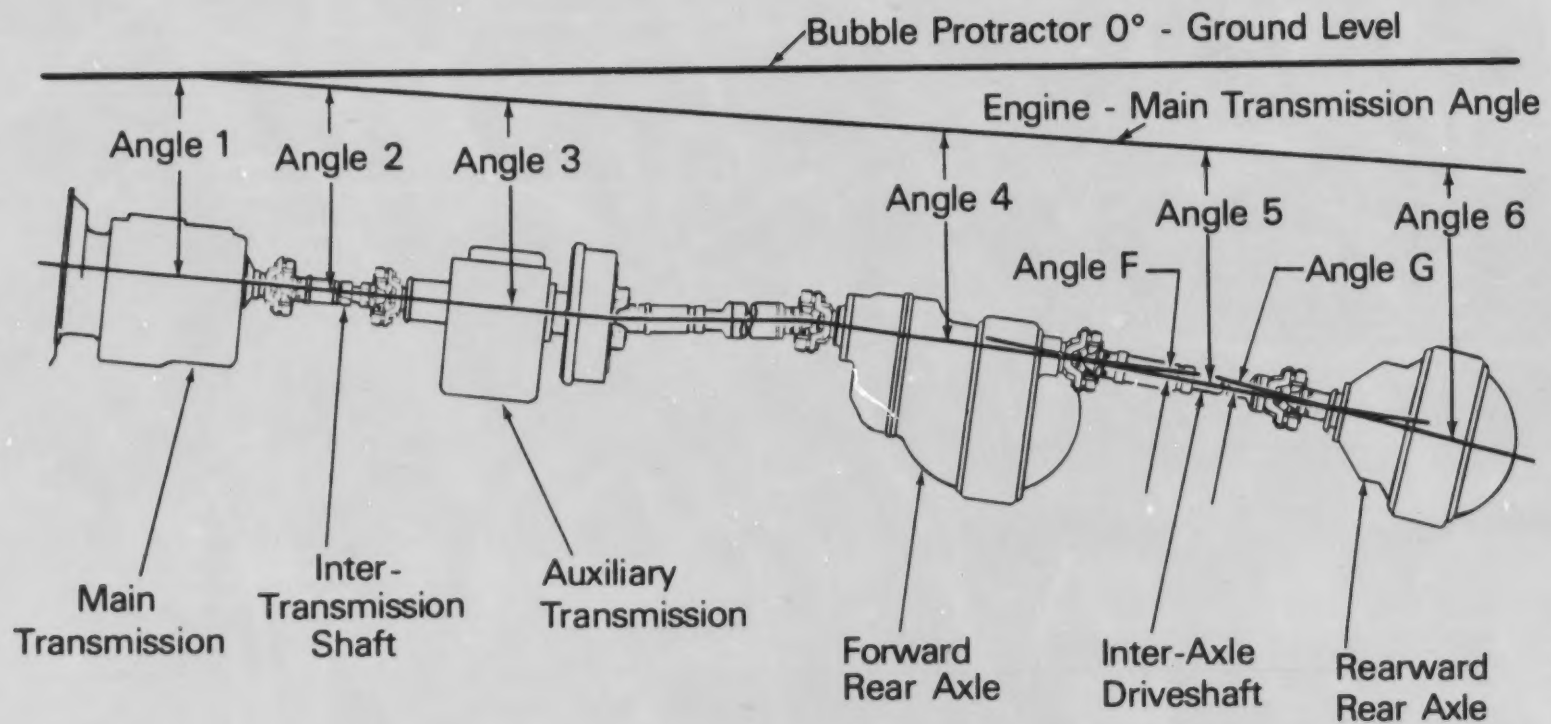
DRIVE LINES
UNIT VI

JOB SHEET #4--ALIGN AND TIME A TELESCOPING DRIVE LINE

- I. Tools and equipment
 - A. Spirit level protractor, or magnetic base protractor
 - B. Basic hand tool set
 - C. Chock block
 - D. Creeper
 - E. Safety glasses
 - F. Vehicle manufacturer's service manual
- II. Procedure
 - A. Take degree reading of transmission
 - 1. Place vehicle on level floor
 - 2. Place protractor on machined pad of engine or transmission

(NOTE: It is important that this pad be one which is parallel or perpendicular to the engine-transmission center line. Make sure that surface is clean and smooth.)
 - 3. Record reading on Figure 1, Angle one

JOB SHEET #4
FIGURE 1



Courtesy Ford Motor Company

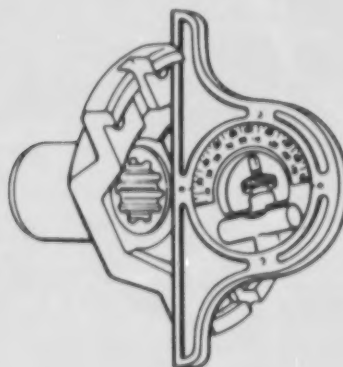
JOB SHEET #4

B. Take degree reading of intertransmission shaft

1. Clean foreign material from shaft
2. Take reading from flat surface of shaft or tubing parallel to center line of shaft
3. Record reading on Figure 1, Angle two

C. Take degree reading of auxiliary transmission

1. Remove front or rear U-joint from auxiliary transmission yoke
(NOTE: Remove the U-joint that is the easiest to remove.)
2. Take reading from U-joint yoke (Figure 2)



Courtesy Ford Motor Company

3. Record reading on Figure 1, Angle 3

(NOTE: While U-joint is removed, make physical inspection of U-joint and make necessary corrections.)

D. Take degree reading on front rear axle

1. Remove input shaft U-joint from yoke on front rear axle or find a machined pad perpendicular or parallel to center line of input shaft on differential or axle housing
2. Take degree reading
3. Record degree reading on Figure 1, Angle 4

JOB SHEET #4

- E. Take degree reading of interaxle drive shaft
1. Clean spot on drive shaft tubing of foreign material
 2. Take degree reading on clean spot of drive shaft tubing
 3. Record reading on Figure 1, Angle 5
- F. Take degree reading of rear rear axle
1. Remove interaxle drive shaft U-joint from input shaft yoke or find a machined pad on differential or axle housing parallel or perpendicular to center line of input shaft
 2. Take degree reading
 3. Record reading on Figure 1, Angle 6
- G. Locating points of drive train misalignment
1. Compare recorded degrees (Figure 1)
 2. Any unit varying more than $\frac{1}{4}$ to $\frac{1}{2}^\circ$ from engine-transmission (except rear rear axle) is misaligned
- H. Intertransmission drive line and auxiliary transmission for misalignment
1. Correct intertransmission drive line angle by moving auxiliary transmission

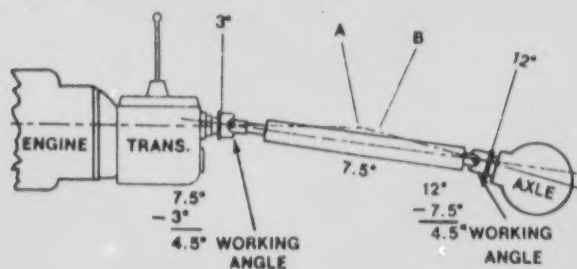
(NOTE: If intertransmission drive line angle is less than engine angle, the auxiliary transmission will have to be lowered until angle is correct; if the drive line angle is more than transmission angle, the auxiliary transmission will have to be raised, and when relocating auxiliary, make sure to keep auxiliary angle the same as transmission angle.)
 2. Correct auxiliary transmission angle by raising or lowering front or rear of auxiliary with shim under mounts
- J. Correcting front differential for misalignment
1. If front axle angle is more than transmission, add shims under rear torque arm mount at cross member
 2. If front axle angle is less than transmission, remove shims from under torque arm

JOB SHEET #4

K. Correcting alignment of rear rear axle and interaxle drive line

1. Interaxle drive line has broken back angle
2. Working angles have to be equal (Figure 3)

(NOTE: If front differential is 3° and interaxle drive line is 7.5° , subtract $7.5^\circ - 3^\circ = 4.5^\circ$ then add $7.5^\circ + 4.5^\circ = 12^\circ$. The rear rear axle angle would have to be $12^\circ \frac{1}{4}$ to $\frac{1}{2}$.)



Courtesy Eaton Corporation

L. Time telescoping drive line

1. Make sure all drive lines are in time
2. Drive lines are in time when the yokes on both ends are in the same plane

DRIVE LINES
UNIT VI

JOB SHEET #5--BALANCE A PROPELLER SHAFT

I. Tools and equipment

- A. Hose clamp (slightly larger than propeller shaft)
- B. Chalk, crayon, or pencil
- C. Jack stands, 5
- D. Floor jack

(NOTE: Use a twin-post hoist if available.)

- E. Basic hand tool set
- F. Safety glasses
- G. Small strips of steel for weights (1/8" X 1/2" X 1")
- H. Welding equipment as required

II. Procedure

(NOTE: If a balance problem exists, the propeller shaft should be cleaned of build-up of foreign materials and checked to determine if any balance weights have been lost and that the shaft is properly installed. Road test after cleaning. If the problem still exists, disconnect the propeller shaft from the pinion and rotate 180 degrees. Reconnect propeller shaft and road test again. If the problem still exists, balance the propeller shaft using the following procedure.)

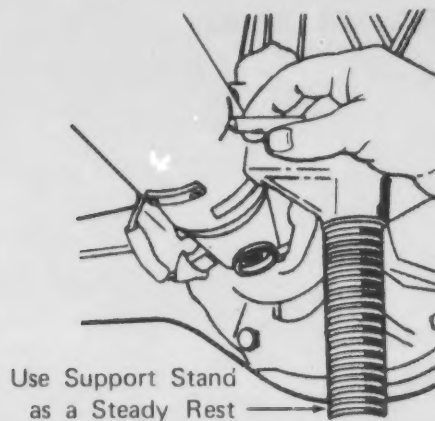
- A. Place the vehicle on jack stands so that the rear of the vehicle is supported on the rear axle housing with the wheels free to rotate
- B. Set a jack stand approximately 1 inch (25.4 mm) from the propeller shaft (Figure 1)
- C. Start the engine and rotate the propeller shaft at 40-50 mph (65-80 km/h)

JOB SHEET #5

- D. Mark the propeller shaft by carefully bringing the crayon or pencil up until it just barely contacts the rear end of the spinning propeller shaft (Figure 1)

(CAUTION: Avoid contact with the spinning shaft and tires. While marking the shaft, avoid areas where balance weights are located because they could injure your hands.)

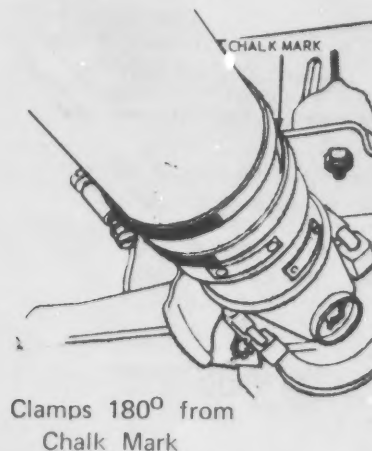
FIGURE 1



(NOTE: The mark made by the crayon or pencil will indicate the heavy side of the shaft.)

- E. Turn off the engine
- F. Install one screw type hose clamp on the rear of the propeller shaft so that the screw head is 180 degrees from the mark on the propeller shaft (Figure 2)

FIGURE 2



JOB SHEET #5

- G. Tighten clamp securely
- H. Run the vehicle up to 40-50 mph (104-112 km/h) speedometer reading or range of vibration

(NOTE: If no vibration is felt, road test the vehicle as a final test. If vibration still exists, proceed as follows.)

- I. Install heavier weight under hose clamp screw
- J. Continue to add weight and test until vibration is eliminated
- K. Weld weights to shaft being careful not to overheat shaft

DRIVE LINES
UNIT VI

NAME _____

TEST

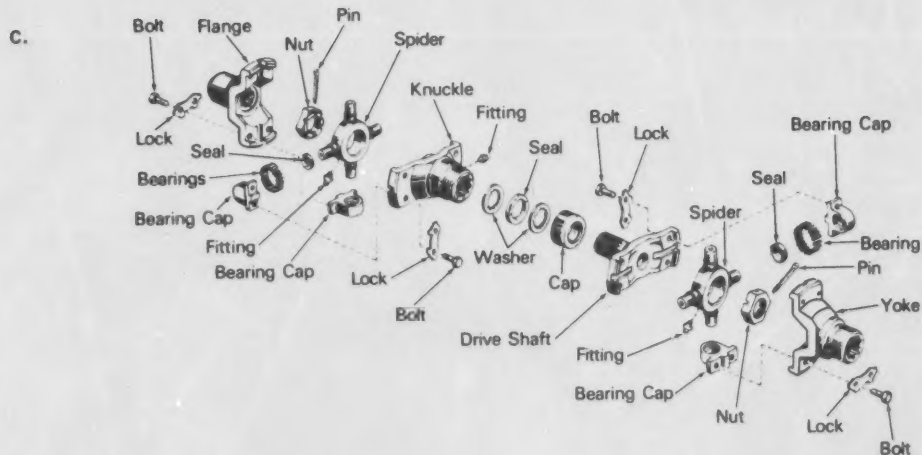
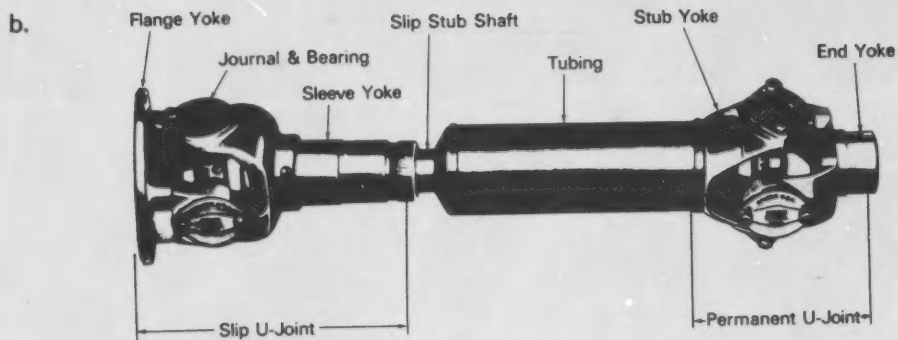
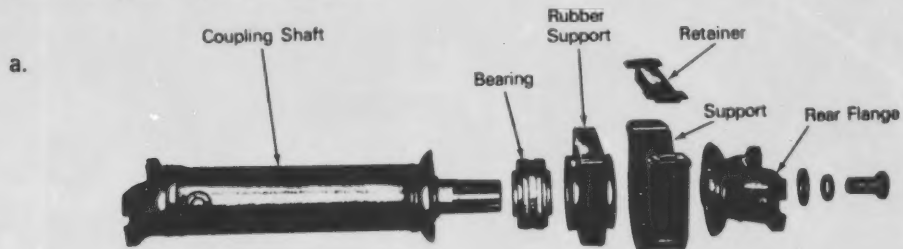
1. Match the terms on the right with their correct definitions.

- | | |
|---|---------------------------------|
| _____ a. All companion flanges or yokes in the drive line are parallel to each other with working angles of the joints equal and opposite | 1. Slip joint |
| _____ b. The working angles of the joints are equal, but the yokes are nonparallel | 2. Parallel U-joint arrangement |
| _____ c. A flexible coupling that permits a driving shaft to operate between two power train units that are not in perfect alignment with each other and are subject to movement | 3. Center support bearing |
| _____ d. Shaft that connects two units of the drive train to propel vehicle | 4. Universal joint |
| _____ e. Driving connection made up of one or more propeller shafts between two or more units of the drive train | 5. U-joint timing |
| _____ f. Two closely coupled cross and roller U-joints arranged so that their acceleration-deceleration effects cancel each other, resulting in output propeller shaft speed identical to input speed | 6. Propeller shaft |
| _____ g. Variable-length connection at one end of a propeller shaft that allows the shaft to vary in length | 7. Drive line |
| _____ h. Cross and roller U-joint | 8. Cardon joint |
| _____ i. Propeller shaft runout or unbalance condition causing the shaft to arc similar to the looping action of a rope held at both ends and swung in an arc | 9. Broken back arrangement |
| _____ j. Procedure of aligning the yokes of a propeller shaft parallel to each other | 10. Constant velocity U-joint |
| _____ k. A bearing and mount assembly used to support the rear of a drive shaft when two or more drive shafts are used | 11. Whirl |

2. List two characteristics of a hotchkiss drive.

a. _____ b. _____

3. Identify types of propeller shafts.

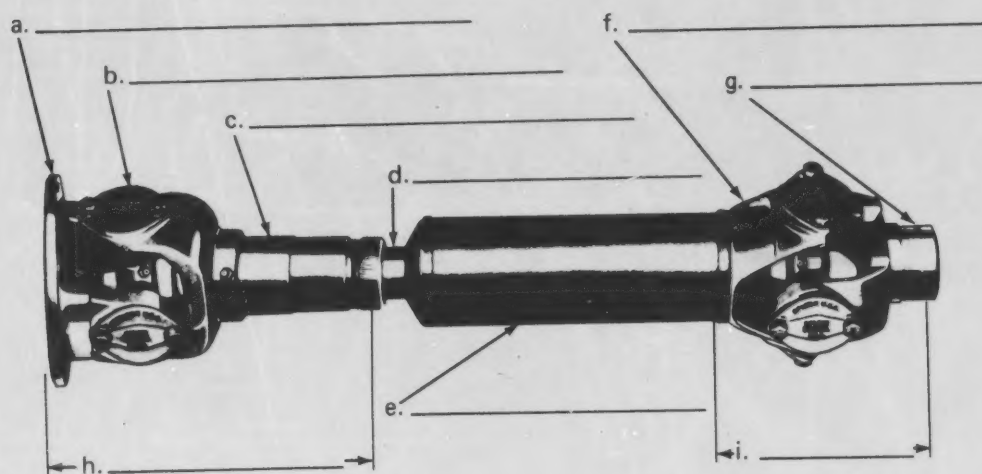


a. _____

b. _____

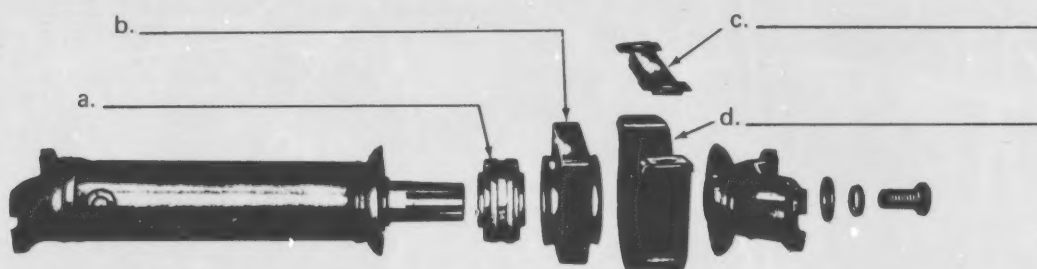
c. _____

4. Identify parts of a propeller shaft with slip yoke.



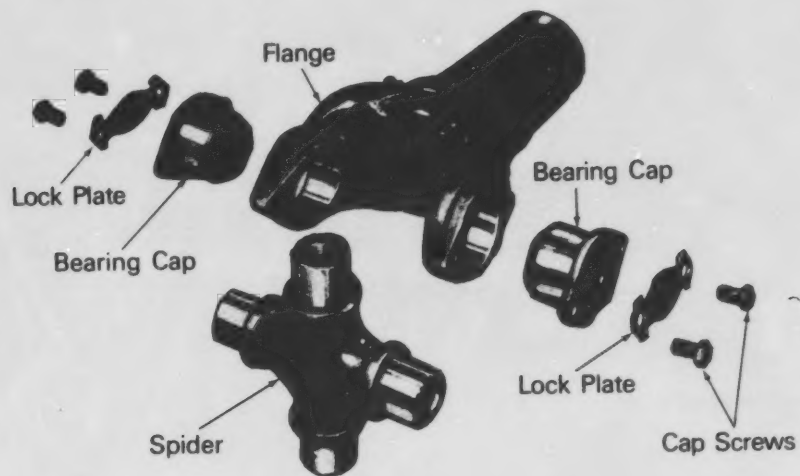
- a. _____
- b. _____
- c. _____
- d. _____
- e. _____

5. Identify parts of a center bearing.

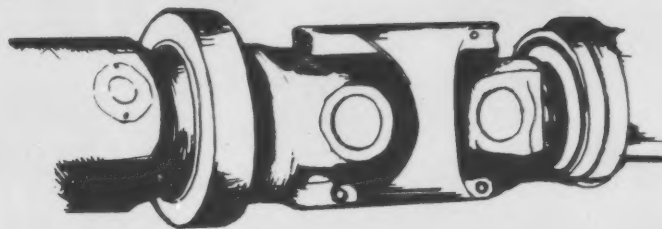


- a. _____
- b. _____
- c. _____
- d. _____

6. Differentiate between constant velocity and cross and roller U-joints by correctly labeling the illustrations below.

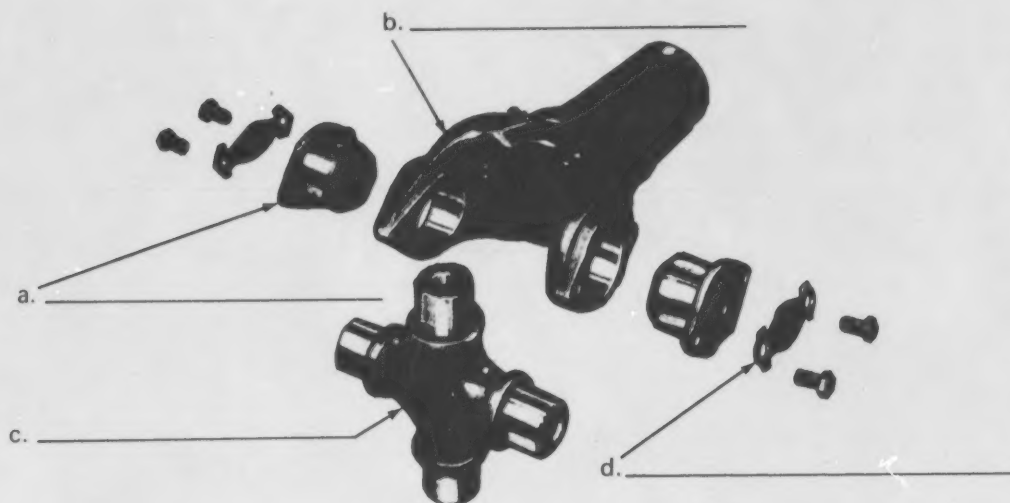


a. _____



b. _____

7. Identify parts of a cross and roller U-joint.



8. Select points on a drive train to check component angles by placing an "X" in the appropriate blanks.

- _____ a. Top of auxiliary
- _____ b. Interaxle drive line on clean tubing
- _____ c. Machined pad on rear of transmission
- _____ d. Coupling driveshaft on clean tubing section
- _____ e. Front yoke or flange of auxiliary transmission
- _____ f. Radiator mount pad

9. Select true statements concerning acceleration-deceleration of propeller shaft with cardon U-joints by placing an "X" in the appropriate blanks.

- _____ a. Input side of U-joint turns at constant r.p.m.
- _____ b. Output of U-joint accelerates and decelerates once during three revolutions of the shaft
- _____ c. The greater the U-joint angle the greater the effect will be

10. Complete the following list of problems causing drive line noise or vibration.

- a. Out of balance emergency brake drum on rear of transmission or auxiliary
- b. Lack of lubrication in the U-joints
- c. Worn U-joint bearings
- d. Bind in slip yoke
- e. Sprung or damaged drive shaft
- f. _____
- g. Drive shaft U-joint out of time
- h. Foreign material on drive shaft
- i. _____
- j. Loose or worn rear suspension
- k. Excessive drive shaft angles

11. Demonstrate the ability to:

- a. Remove and replace a propeller shaft.
- b. Disassemble, inspect, and reassemble a U-joint with bolted end.
- c. Remove and replace a cross and roller U-joint.
- d. Align and time a telescoping drive line.
- e. Balance a propeller shaft.

(NOTE: If these activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

DRIVE LINES
UNIT VI

ANSWERS TO TEST

- | | | | | | |
|-------|---|----|----|----|----|
| 1. a. | 2 | e. | 7 | i. | 11 |
| b. | 9 | f. | 10 | j. | 5 |
| c. | 4 | g. | 1 | k. | 3 |
| d. | 6 | h. | 8 | | |
2. a. Open U-joints
b. Exposed drive line
3. a. Coupling shaft and center support bearing
b. Propeller shaft with slip yoke
c. Coupling shaft without center bearing
4. a. Flange yoke
b. Journal and bearing
c. Sleeve yoke
d. Slip stub shaft
e. Tubing
f. Stub yoke
g. End yoke
h. Slip U-joint
i. Permanent U-joint
5. a. Bearing
b. Rubber support
c. Retainer
d. Support
6. a. Cross and roller
b. Constant velocity
7. a. Bearing cap
b. Yoke
c. Spider
d. Lock plate
8. b, c, d, e
9. a, c
10. f. Missing balance weight
i. Loose or worn engine mounts
11. Performance skills evaluated to the satisfaction of the instructor

DIFFERENTIALS AND FINAL DRIVES UNIT VII

UNIT OBJECTIVE

After completion of this unit, the student should be able to identify the components of differentials and final drives. The student should also be able to make bearing adjustments, identify different tooth patterns, and be able to remove, repair, and replace differentials and final drives. This knowledge will be evidenced by correctly performing the procedures outlined in the job sheets and by scoring 85 percent on the unit test.

SPECIFIC OBJECTIVES

1. Match terms related to differentials and final drives with their correct definitions.
2. Match types of differentials and final drives with their definitions.
3. Identify parts of a gear tooth.
4. Match the methods used to evaluate gear tooth contact patterns with the correct diagrams.
5. Identify parts of a differential.
6. Identify parts of a planetary gearset.
7. Match planetary gearset components with their characteristics.
8. Name three types of differential locks.
9. Select from a list the purposes of a power divider.
10. Identify the basic parts of a power divider.
11. Match types of shifting mechanisms with their descriptions.
12. Distinguish between flared and compression fittings.
13. Demonstrate the ability to:
 - a. Remove a differential assembly.
 - b. Disassemble a differential case and gear assembly.
 - c. Clean and inspect a differential case and gear assembly.
 - d. Adjust drive pinion bearing preload.

- e. Reassemble a differential case and gear assembly.
- f. Adjust differential bearing preload; check gear backlash and tooth contact pattern.
- g. Install differential assembly in differential housing.
- h. Remove, repair, and reassemble a differential carrier and power divider assembly.
- i. Disassemble a planetary gear assembly outer ends.
- j. Clean and inspect parts of a planetary axle.
- k. Reassemble a planetary gear assembly.
- l. Adjust a planetary gear bearing preload.
- m. Perform preventive maintenance on differential and final drives.
- n. Assemble air line with reusable fitting (flared).
- o. Assemble air line with compression fittings.

DIFFERENTIALS AND FINAL DRIVES UNIT VII

SUGGESTED ACTIVITIES

- I. Provide student with objective sheet.
- II. Provide student with information and job sheets.
- III. Make transparencies.
- IV. Discuss unit objectives.
- V. Discuss information sheet.
- VI. Demonstrate and discuss the procedures outlined in the job sheets.
- VII. Take students on field trip to industry that manufactures or services differential and final drives.
- VIII. Bring different differential and final drive components into shop and show students how each component is different in design.
- IX. Have a differential and final drive disassembled and laid out on shop bench and show students how the parts work together.
- X. Have a mechanic from industry come in and talk to students about what is expected of them when they go to work on differentials and final drives.
- XI. Give test.

INSTRUCTIONAL MATERIALS

- I. Included in this unit:
 - A. Objective sheet
 - B. Information sheet
 - C. Transparency masters
 1. TM 1--Gear Tooth Nomenclature
 2. TM 2--Ring and Pinion Gear
 3. TM 3--Parts of a Planetary Gearset
 4. TM 4--Single Reduction Axle Assembly
 5. TM 5--Double Reduction Axle
 6. TM 6--2-Speed Axle

7. TM 7--Tandem Drive Axle
8. TM 8--Planetary Double Reduction Axle
9. TM 9--Planetary Drive Axles
10. TM 10--Tooth Contact Patterns
11. TM 11--Parts of a Differential
12. TM 12--Types of Differential Locks
13. TM 13--Types of Differential Locks (Continued)
14. TM 14--Parts of a Power Divider
15. TM 15--Parts of a Power Divider (Continued)
16. TM 16--Electric Shift System
17. TM 17--2-Speed Single Axle Straight-Air Shift System
18. TM 18--2-Speed Tandem Axle Straight-Air Shift System
19. TM 19--3-Speed Tandem Axle Straight-Air Shift System
20. TM 20--Types of Air Line Fittings

D. Job sheets

1. Job Sheet #1--Remove a Differential Assembly
2. Job Sheet #2--Disassemble a Differential Case and Gear Assembly
3. Job Sheet #3--Clean and Inspect a Differential Case and Gear Assembly
4. Job Sheet #4--Adjust Drive Pinion Bearing Preload
5. Job Sheet #5--Reassemble a Differential Case and Gear Assembly
6. Job Sheet #6--Adjust Differential Bearing Preload; Check Gear Backlash and Tooth Contact Pattern
7. Job Sheet #7--Install Differential Assembly In Differential Housing
8. Job Sheet #8--Remove, Repair, and Reassemble a Differential Carrier and Power Divider Assembly
9. Job Sheet #9--Disassemble a Planetary Gear Assembly Outer Ends
10. Job Sheet #10--Clean and Inspect Parts of a Planetary Axle
11. Job Sheet #11--Reassemble a Planetary Gear Bearing Preload
12. Job Sheet #12--Adjust a Planetary Gear Assembly

13. Job Sheet #13--Perform Preventive Maintenance on Differential and Final Drives

14. Job Sheet #14--Assemble Air Line with Reusable Fitting (Flared)

15. Job Sheet #15--Assemble Air Line with Compression Fittings

E. Test

F. Answers to test

II. References:

A. Forier, Louis C. *Motor Trucks and Diesel Repair Manual*. 33rd Edition. New York, NY 10010: Motor, 1980.

B. Notgrass, Troy. *The Automotive Power Train Mechanic*. Austin, TX: Instructional Materials Service Division of Extension, The University of Texas at Austin, 1973.

C. *Fundamentals of Service: Power Trains*. Moline, IL 61265: John Deere Service Publications, Dept. F, 1972.

D. *1968 Ford Truck Shop Manual*. Dearborn, MI: Ford Service Publications, 1968.

E. Stockel, Martin W. *Auto Service and Repair*. South Holland, IL: The Goodheart-Wilcox Co., Inc., 1969.

F. *Field Maintenance for Rockwell-Standard Off-Highway Vehicles Employing Planetary Axles*. Troy, MI 48084: Rockwell International Automotive Headquarters, 1976.

G. *Eaton Truck Axles, Service Manual EA-104*. Cleveland, OH 44110: Eaton Corporation, Axle Division, 1977.

H. *Eaton Truck Axles, Service Manual EA-104*. Cleveland, OH 44110: Eaton Corporation, Axle Division, 1980.

I. Schulz, Erich J. *Diesel Equipment II*. Dallas, TX: Gregg Division, McGraw-Hill, Inc., 1982.

DIFFERENTIALS AND FINAL DRIVES UNIT VII

INFORMATION SHEET

I. Terms and definitions

- A. Differential--Arrangement of gears connecting two shafts or axles in the same line, dividing the driving force equally between them, and permitting one shaft to revolve faster than the other (also known as third member)
- B. Final drive--The last phase of the power train; it gives the final reduction in speed and increase in torque to the drive wheels
- C. Backlash--Distance that one gear can be moved back and forth without moving the gear into which it is meshed (Transparency 1)
- D. Ring gear--Name given to the bevel gear in a differential, and the gear which surrounds or rings the sun and planet gears in a planetary system
- E. Hypoid gear--A gear that is similar in appearance to spiral bevel gear, but the driving gear is located below the center of the driven gear (Transparency 2)
- F. Pinion--A small gear having the teeth formed in the hub; it drives a larger gear
- G. Preload--Adjusting antifriction bearing so that it is under mild pressure; this prevents bearing looseness under a driving stress
- H. Gear tooth clearance--Distance separating two gear teeth that are meshed together (Transparency 1)
- I. Tooth contact pattern test--A method of testing the wiping action between ring gear and pinion gear to determine if they are properly adjusted
- J. Planetary gearset--A gearing unit consisting of a ring gear with internal teeth, a sun or central pinion gear with external teeth, and a series of planet gears that are meshed with both the ring and the sun gear (Transparency 3)
- K. Differential pinion--Small gears mounted on a shaft pinned to the differential case; they mesh with, and drive, the axle end gears

II. Types of differentials and final drives and their definitions

- A. Single reduction axle--Rear axle assembly with single reduction through ring gear and drive pinion (Transparency 4)
- B. Double reduction axle--Rear axle assembly with two reductions; one through ring and drive pinion, one through a set of helical gears (Transparency 5)

INFORMATION SHEET

- C. 2-speed axle--Rear axle assembly with two gear ratios for various road and load conditions (Transparency 6)
- D. Tandem drive axle--Rear axle assembly incorporating two single axle units and power divider interconnected by a propeller shaft (Transparency 7)
- E. Planetary double reduction axle--Rear axle assembly with two reductions; one through ring gear and drive pinion, one through planetary gearing (Transparency 8)
- F. Planetary drive axle--Rear axle assemblies which are more durable because torque loads are spread more evenly over several gears (Transparency 9)

III. Parts of a gear tooth (Transparency 1)

- A. Flank
- B. Pitch line

(NOTE: Remember that pitch line is not physically part of a gear tooth, but an imaginary line used for reference.)

- C. Face
- D. Toe (small end)
- E. Heel (large end)

IV. Methods used to evaluate gear tooth contact patterns (Transparency 10)

(NOTE: Check tooth contact patterns on both sides of tooth, drive side and coast side; the drive side has concave teeth and the coast side has convex teeth.)

- A. On drive side of tooth
 - 1. Should be centrally located between the top and bottom
 - 2. Tends to spread toward the heel of the tooth as the load increases
 - 3. Can be slightly closer to the toe end
- B. On coast side of tooth
 - 1. May be a little longer and closer to the toe end
 - 2. Should be centrally located between the top and bottom

V. Parts of a differential (Transparency 11)

- A. Companion flange (pinion yoke)
- B. Pinion seal and retainer

INFORMATION SHEET

- C. Companion flange flat washer
 - D. Pinion bearing (cone and cup)
 - E. Pinion bearing cage
 - F. Pinion bearing cage shim
 - G. Pinion bearing spacer
 - H. Drive pinion
 - I. Pinion pilot bearing
 - J. Differential carrier
 - K. Carrier gasket
 - L. Differential bearing adjuster
 - M. Differential carrier bearing cap
 - N. Differential bearing cup
 - O. Differential bearing cone
 - P. Differential case, flanged half
 - Q. Ring gear
 - R. Side gear thrust washer
 - S. Side gear
 - T. Spider
 - U. Side pinion
 - V. Side pinion thrust washer
 - W. Differential case, plain half
- VI. Basic parts of a planetary gear differential and final drive (Transparency 3)
- A. Sun gear
 - B. Planet gear
 - C. Planet carrier
 - D. Ring gear

INFORMATION SHEET

VII. Planetary gearset components and their characteristics (Transparencies 8 and 9)

- A. Sun gear--The center gear in mesh with the planet gears

(NOTE: The sun gear can be used as a drive gear as in a final drive or as a driven gear as in a planetary differential.)

- B. Planet gear--Those gears in a planetary gearset that are in mesh with both the ring and the sun gear

(NOTE: They are referred to as planet gears in that they orbit or move around the central or sun gear.)

- C. Planet carrier--That part of a planetary gearset upon which the planet gears are affixed

- D. Ring gear--The large gear with internal teeth in mesh with the teeth of the planet pinions at all times

(NOTE: The ring gear may be attached to the inside of a differential carrier.)

VIII. Types of differentials locks (Transparencies 12 and 13)

(NOTE: The differential lock is used to lock both axle shafts in as one; this prevents the usual loss of traction when one wheel is slipping.)

- A. Mechanical lock--Uses levers and linkages to engage a collar on axle to the splines on differential housing
- B. Hydraulic lock--Uses oil pressure to lock out the differential; when the pedal is depressed the valve allows pressure oil to flow to the differential
- C. Automatic lock--This unit is normally engaged at all times, but still allows for relative motion between the wheels when cornering; when engaged it prevents one wheel from spinning when it loses traction and thereby depriving the other wheel of full driving power

IX. Purposes of a power divider

- A. Equally distributes power from the vehicle transmission to both the forward and rear rear axles
- B. On a tandem drive axle, when power divider is disengaged, the two axles act as two individual axles
- C. When the power divider is engaged the two axles act as one
- D. Provides maximum traction when road conditions are unfavorable

INFORMATION SHEET

- E. When power divider is disengaged it prevents axle fight and permits freer rolling

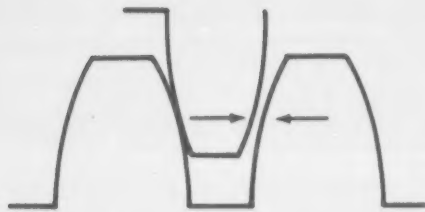
(CAUTION: On a tandem drive axle be sure that both axle ratios are the same.)
- F. Allows for easier steering and better roadability
- X. Parts of a power divider (Transparencies 14 and 15)
 - A. Input shaft
 - B. Inter-axle differential lockout
 - C. Helical side gear
 - D. Pinion helical gear
 - E. Inter-axle differential
- XI. Types of shifting mechanisms (2-speed axles)
 - A. Electric shift (Transparency 16)
 - 1. Consists of a manually-operated control switch and an electric shift unit
 - 2. Connected by electrical cables and normally protected by a circuit breaker
 - 3. The shift unit includes a reversible electric motor, automatic switch, drive screw, and torsion spring drive
 - B. Air-operated shift (Transparencies 17, 18, and 19)
 - 1. Consists of manually operated air shifter valve, a quick release valve, and an axle shift unit
 - 2. Air shifter supplies air through the quick release valve to the axle shift unit
 - 3. Air pressure in the shift unit shifts axle to high range
 - 4. To shift axle to low range, air pressure is exhausted at shifter valve, which exhausts air pressure at quick release valve
 - C. Vacuum-operated shift
 - 1. Consists of a manually operated control lever, vacuum valve controlled by linkages, and an axle shift unit
 - 2. Vacuum can be used to shift the unit to low range
 - 3. Spring tension shifts the unit back to high range

INFORMATION SHEET

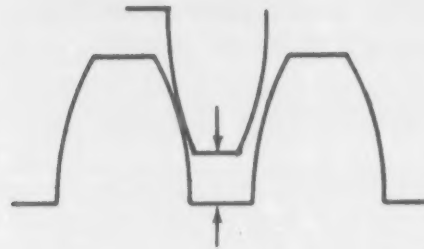
XII. Types of air line fittings (Transparency 20)

- A. Flared fitting--The end of the tubing is spread (flared) outward at an angle
- B. Compression fitting (sleeve)--It is either a separate unit or designed as part of the nut, and when drawn together the sleeve is compressed against the tubing, fitting, and nut

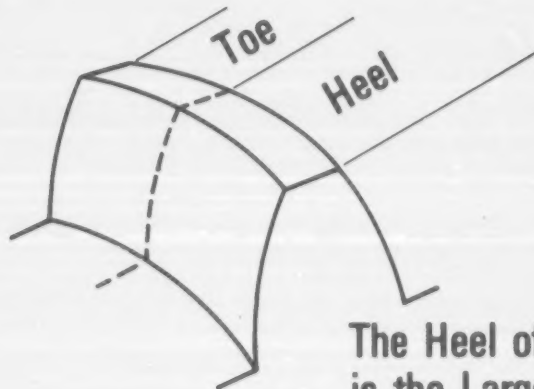
Gear Tooth Nomenclature



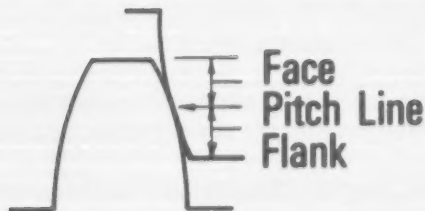
Backlash .006" To .016"



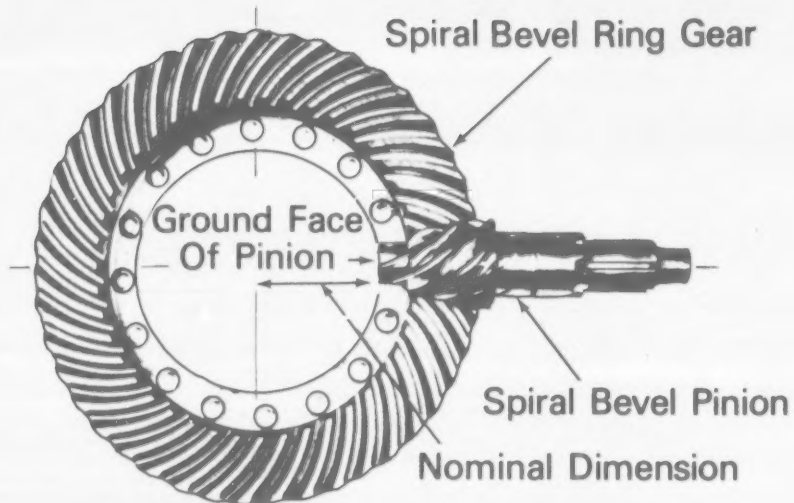
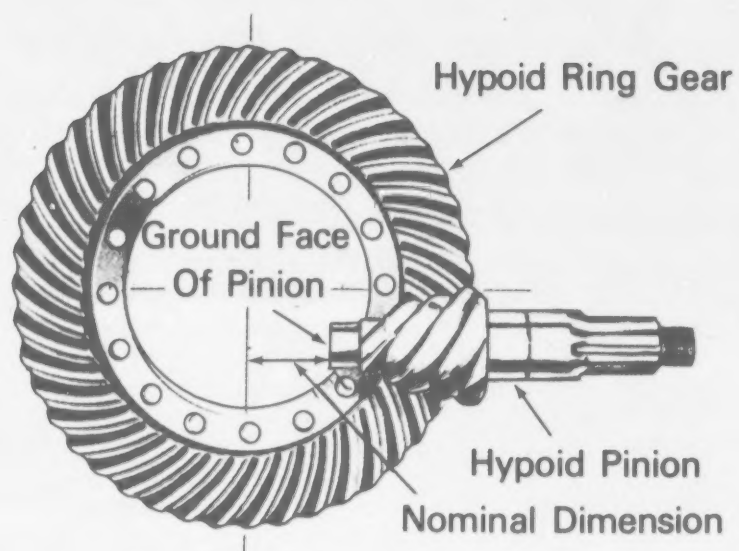
Tooth Clearance



The Heel of the Gear Tooth
is the Large End and the
Toe is the Small End

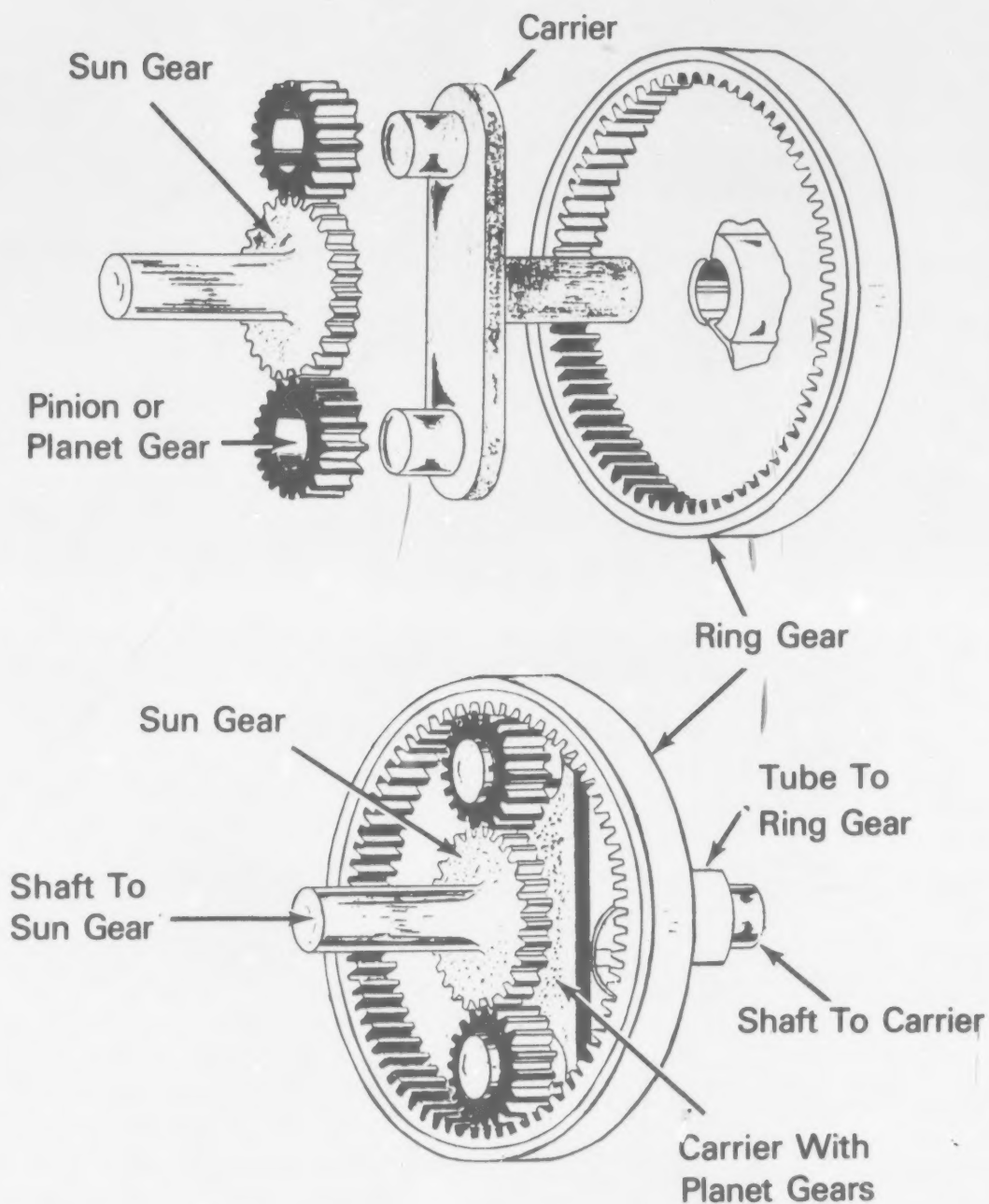


Ring and Pinion Gear

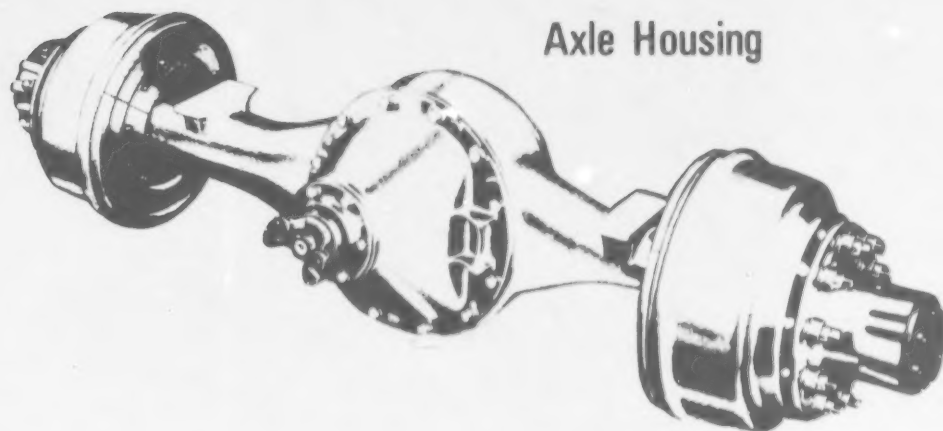


Courtesy International Harvester

Parts Of A Planetary Gearset

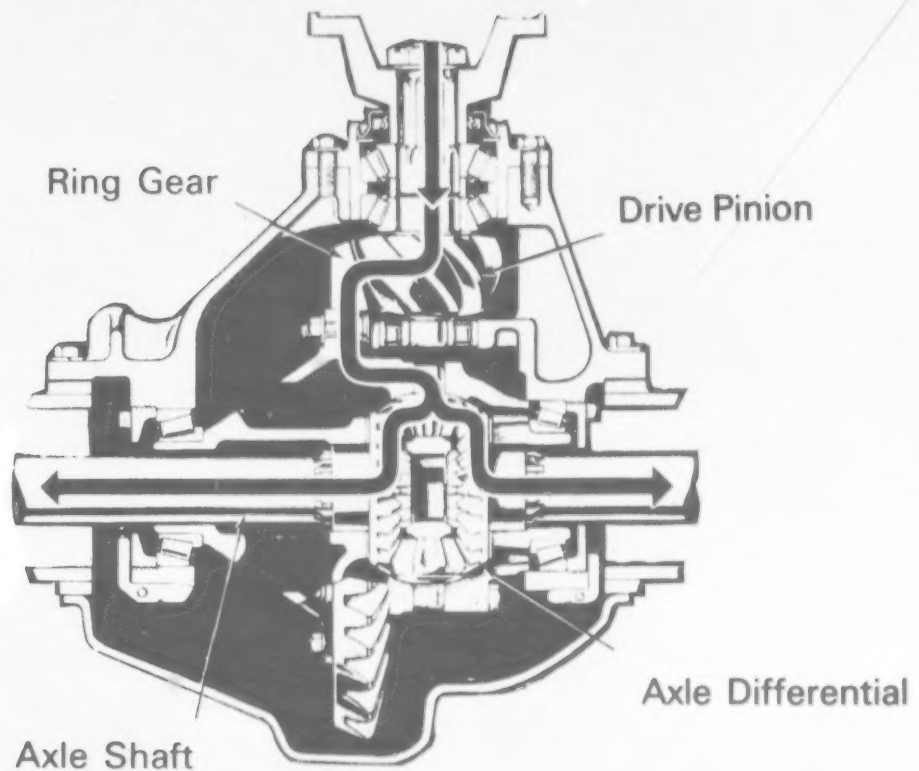


Single Reduction Axle Assembly



Axle Housing

Internal View



Ring Gear

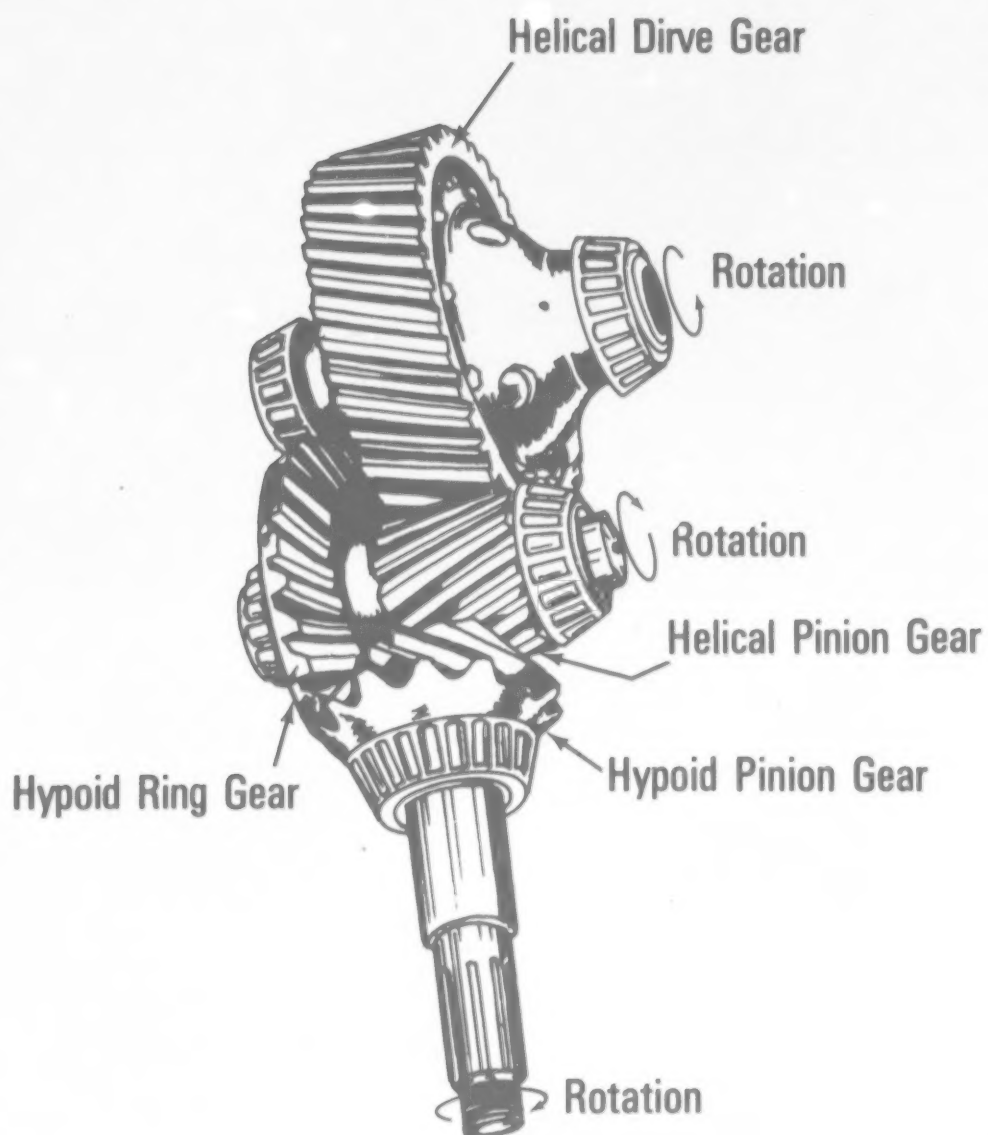
Drive Pinion

Axle Shaft

Axle Differential

Courtesy Transmission Division, Eaton Corporation

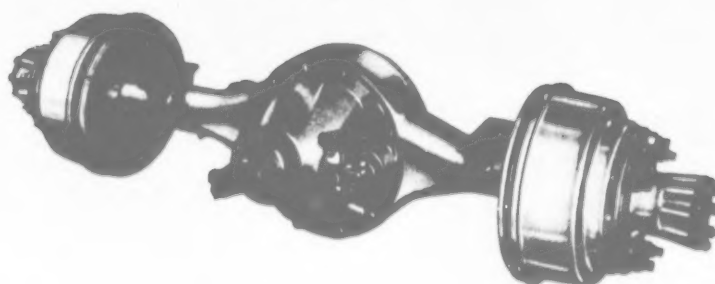
Double Reduction Axle



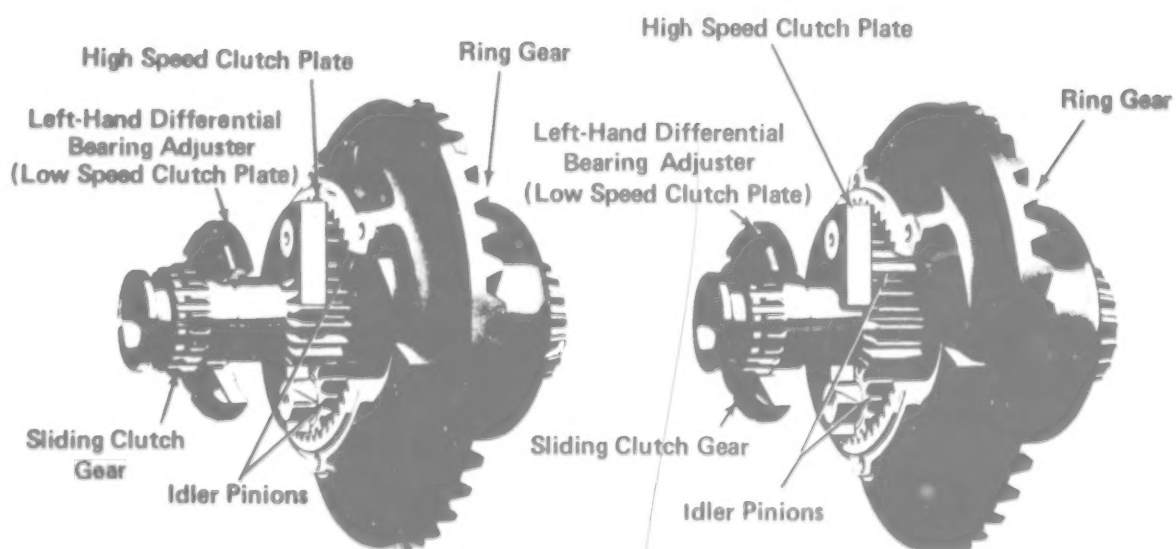
Courtesy Ford Motor Company

2-Speed Axle

Axle Housing

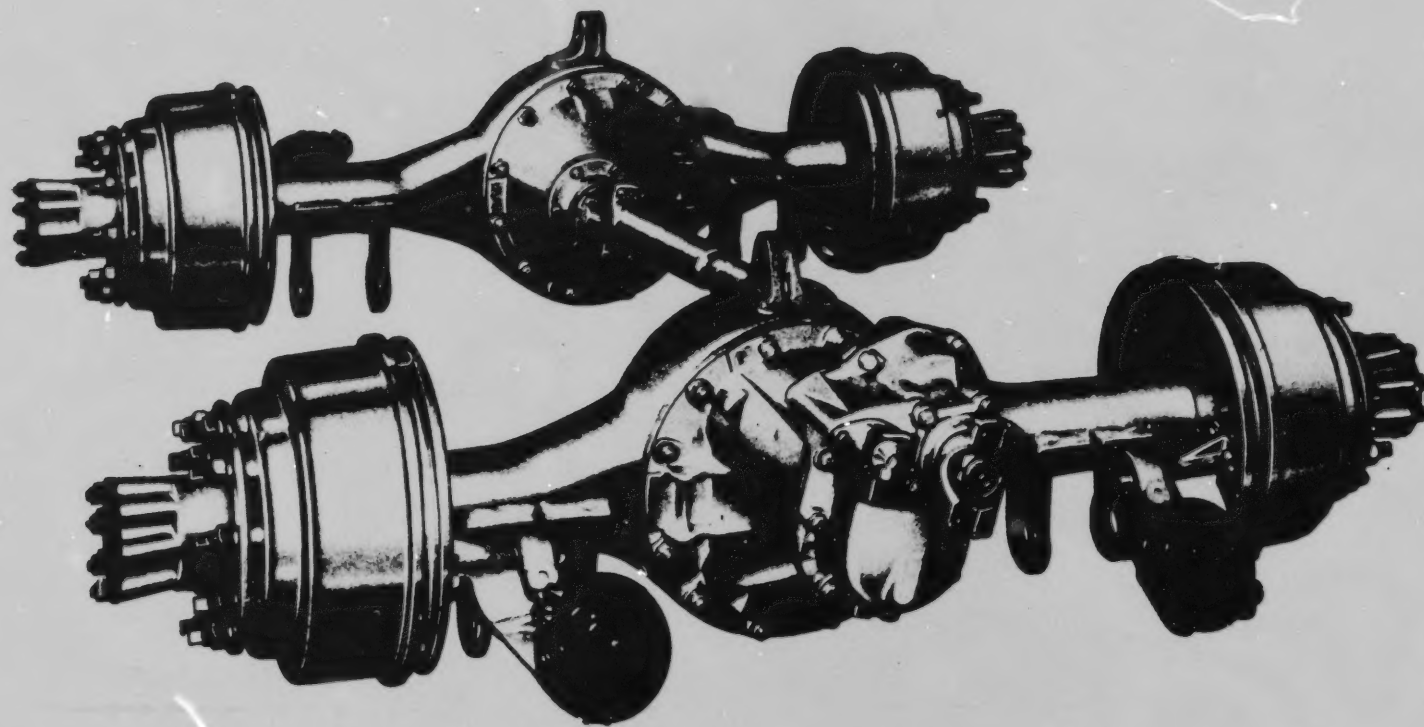


Internal View



Courtesy Transmission Division, Eaton Corporation

Tandem Drive Axle



Axle Housing

Courtesy Transmission Division, Eaton Corporation

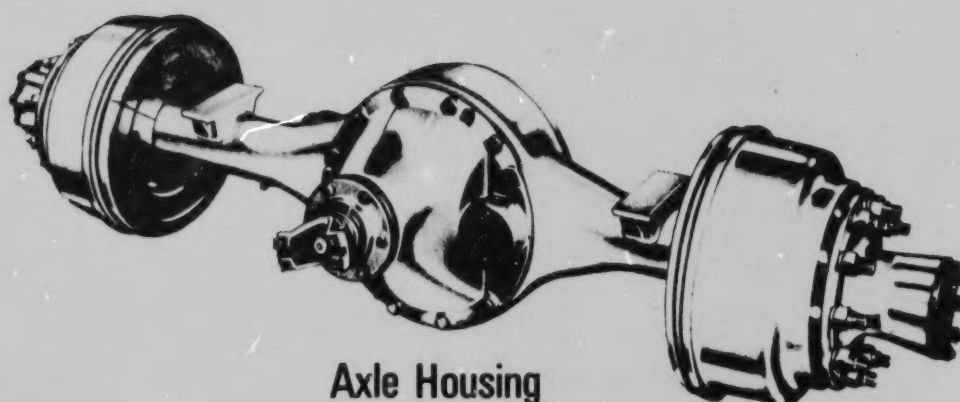
574

TM 7

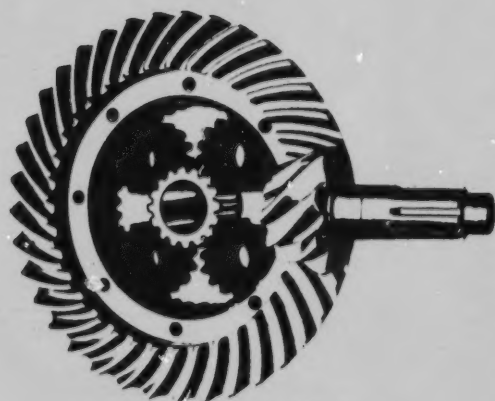
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PT-643

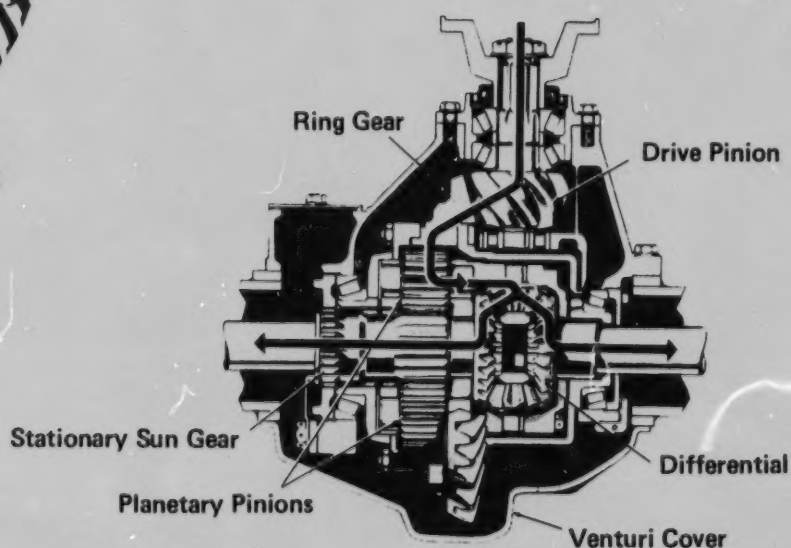
Planetary Double Reduction Axle



Axle Housing



Planetary Gears



Internal View

Courtesy Transmission Division, Eaton Corporation

Tooth Contact Patterns

Pattern A

DRIVE

COAST



Ideal Ring Gear Tooth Contact Under Light Load

Pattern B

DRIVE

COAST



Toe Contact - To Correct Move Gear Away From Pinion

Pattern C

DRIVE

COAST



Heel Contact - To Correct Move Gear Toward Pinion

Pattern D

DRIVE

COAST



High Tooth Contact - To Correct Move Pinion Toward Gear

Pattern E

DRIVE

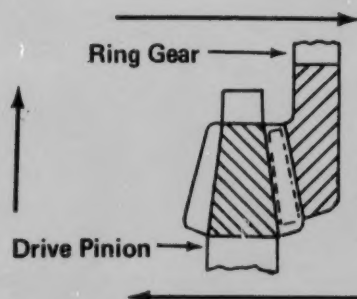
COAST



Low Tooth Contact - To Correct Move Pinion Away From Gear

MOVE RING GEAR AWAY FROM DRIVE PINION
TO CORRECT PATTERN "B"

MOVE DRIVE PINION
TOWARD RING GEAR
TO CORRECT
PATTERN "D"

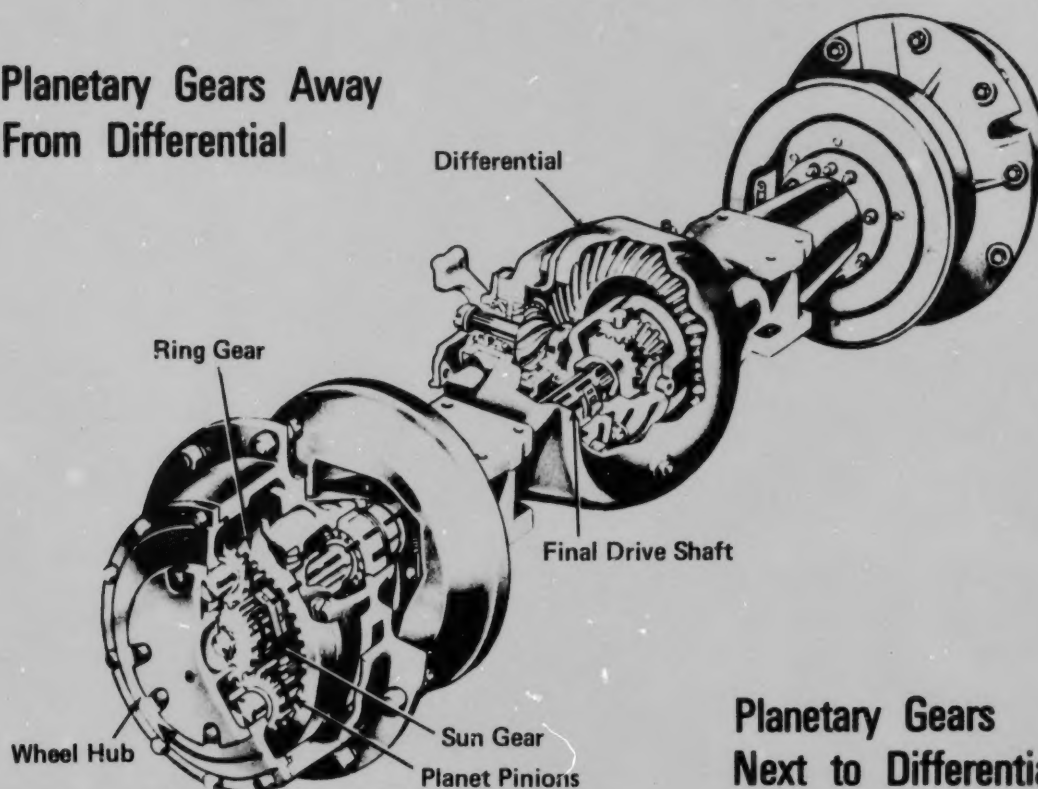


MOVE DRIVE PINION
AWAY FROM RING GEAR
TO CORRECT
PATTERN "E"

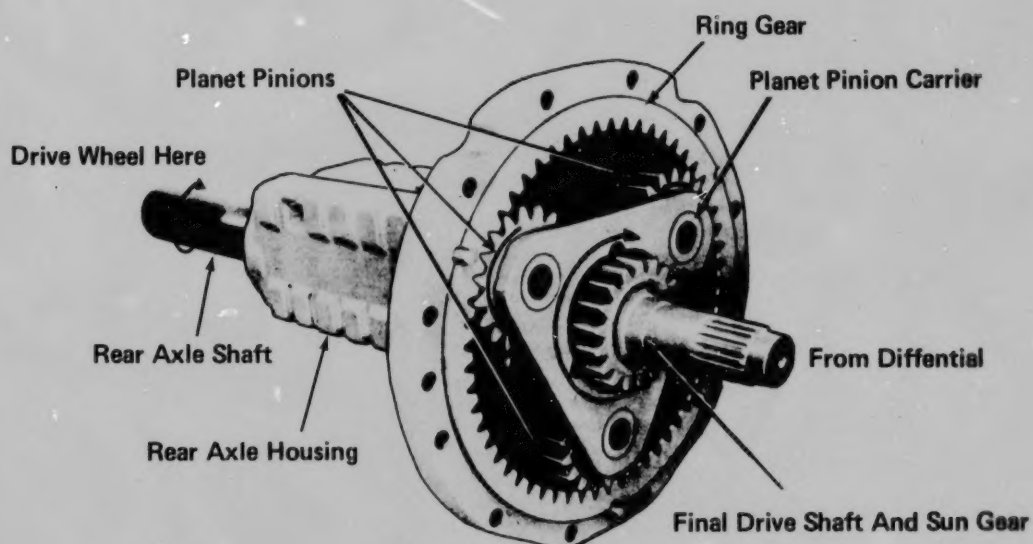
MOVE RING GEAR TOWARD DRIVE PINION
TO CORRECT PATTERN "C"

Planetary Drive Axles

Planetary Gears Away From Differential

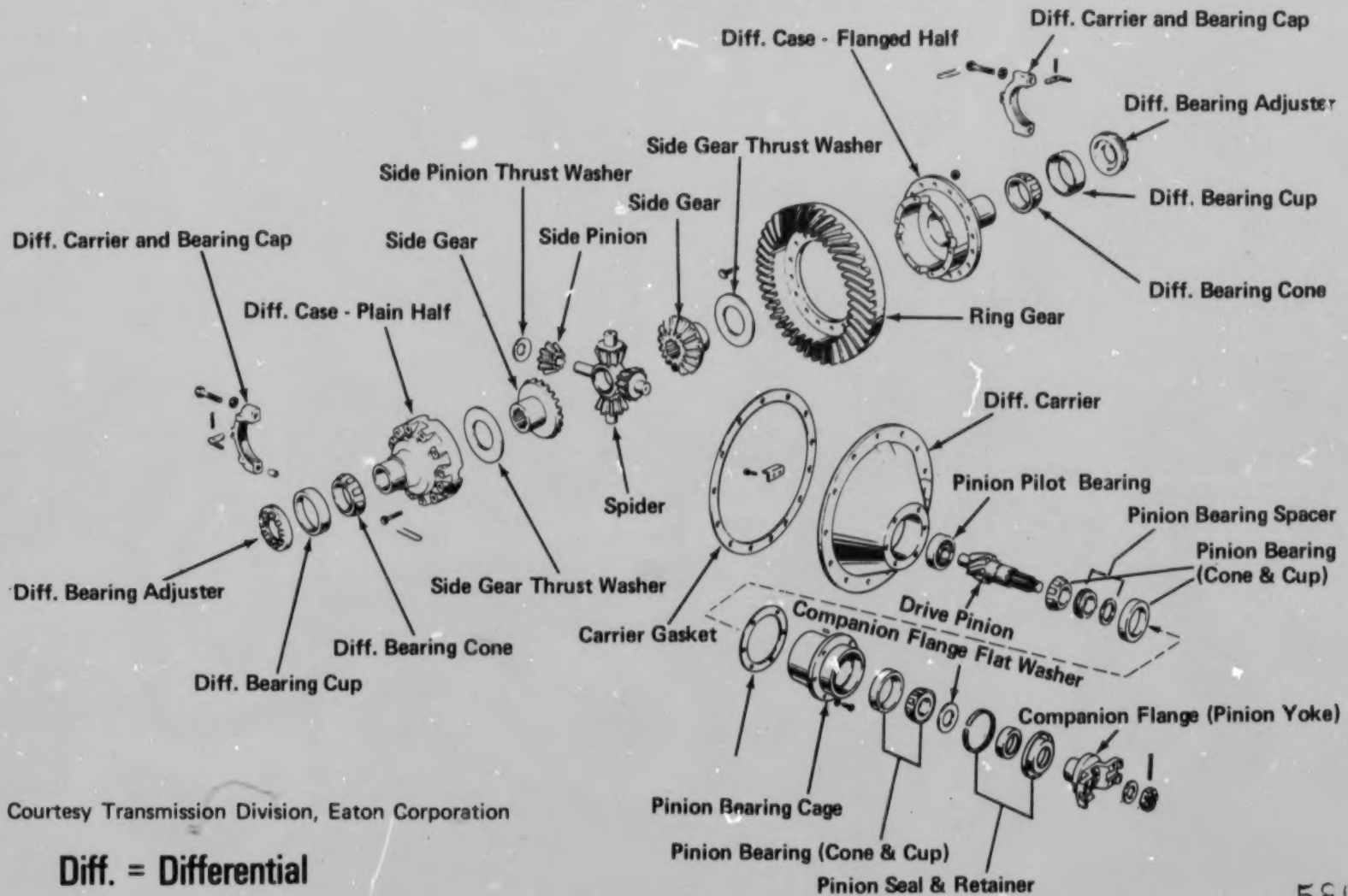


Planetary Gears Next to Differential



Courtesy DEERE & CO., MOLINE, IL

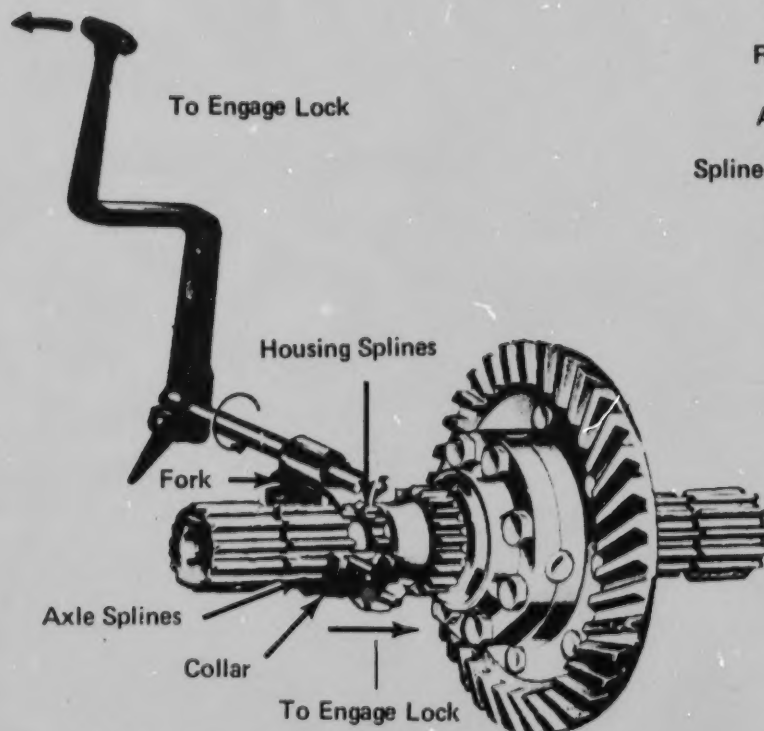
Parts of a Differential



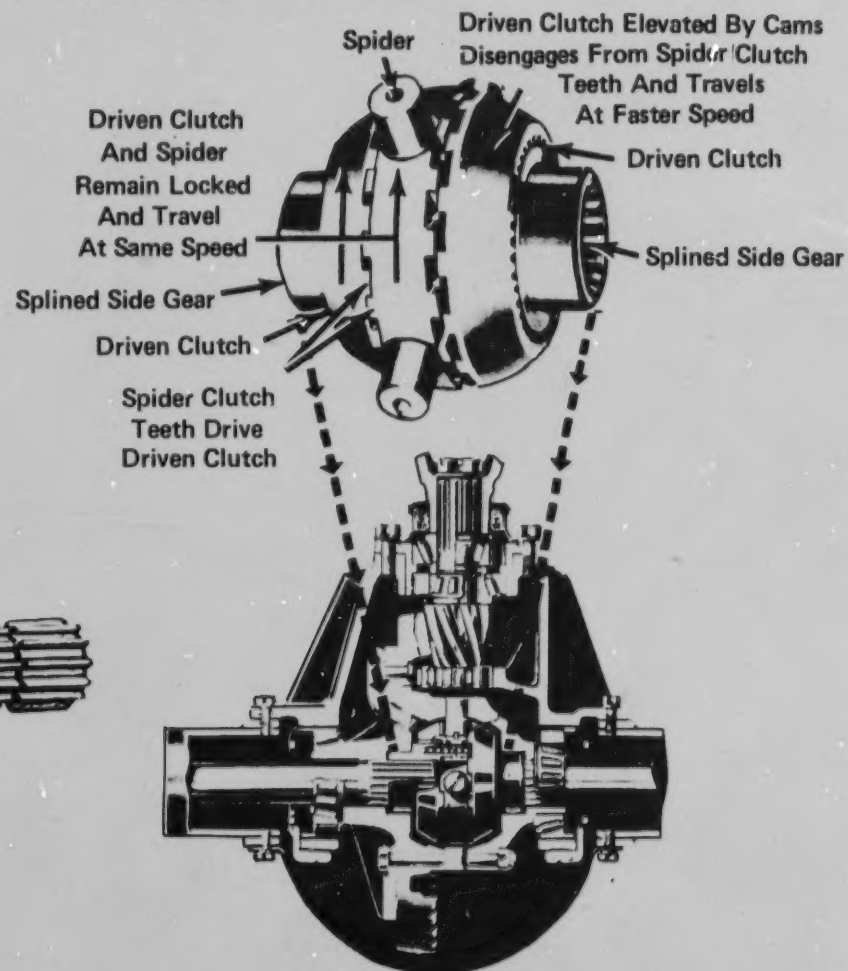
Courtesy Transmission Division, Eaton Corporation

Diff. = Differential

Types of Differential Locks



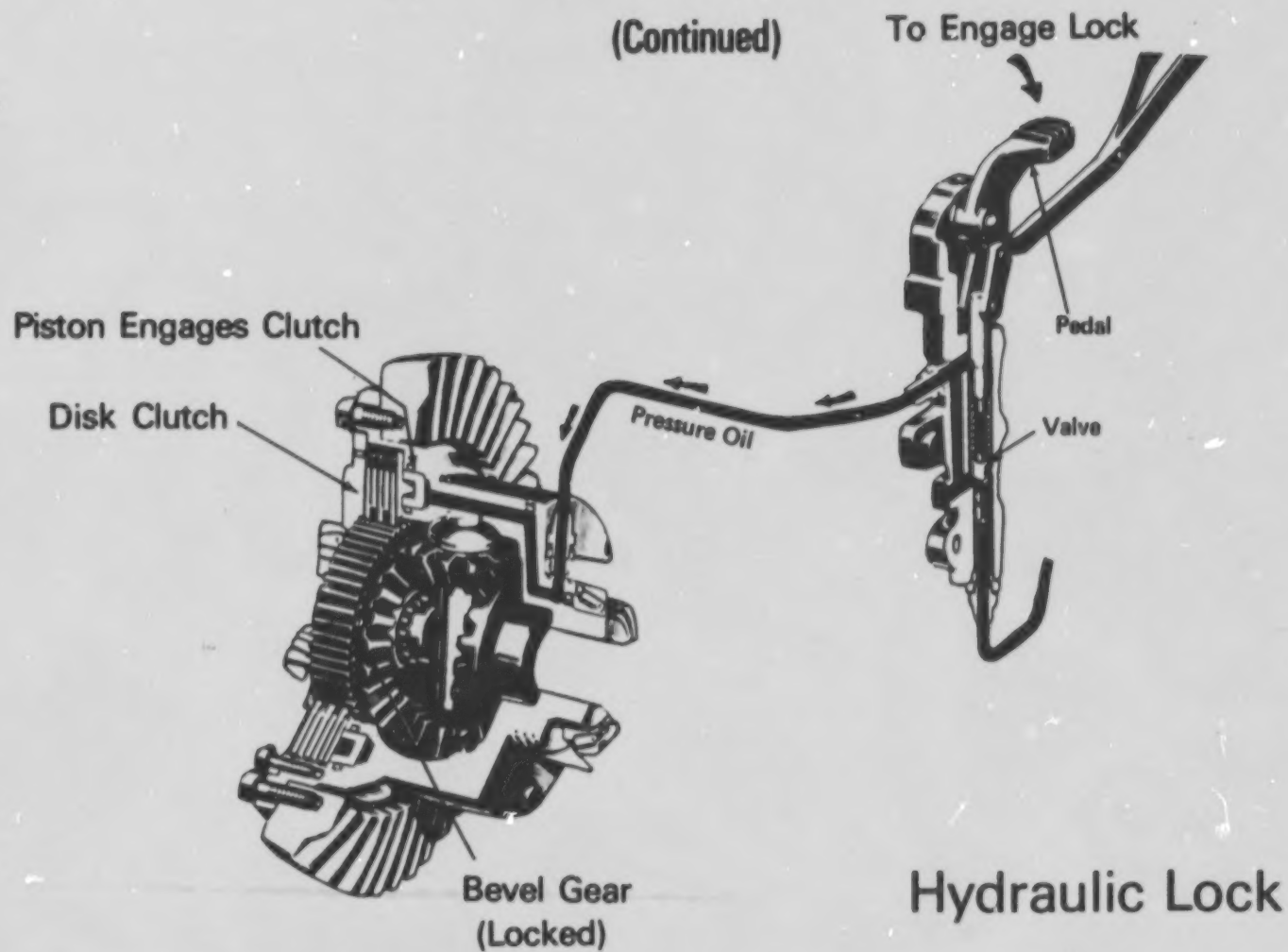
Mechanical Lock



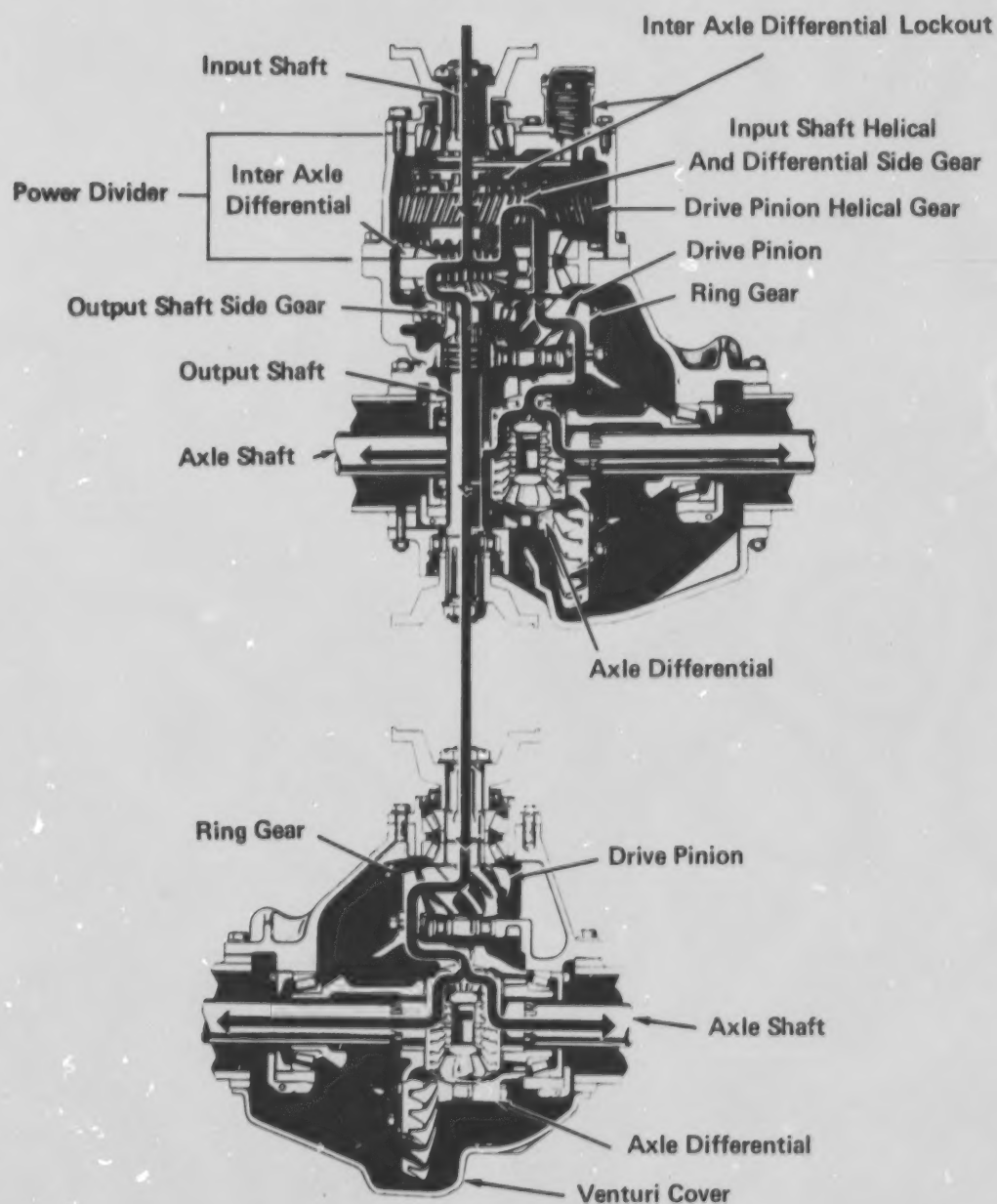
Automatic Lock

Types of Differential Locks

(Continued)



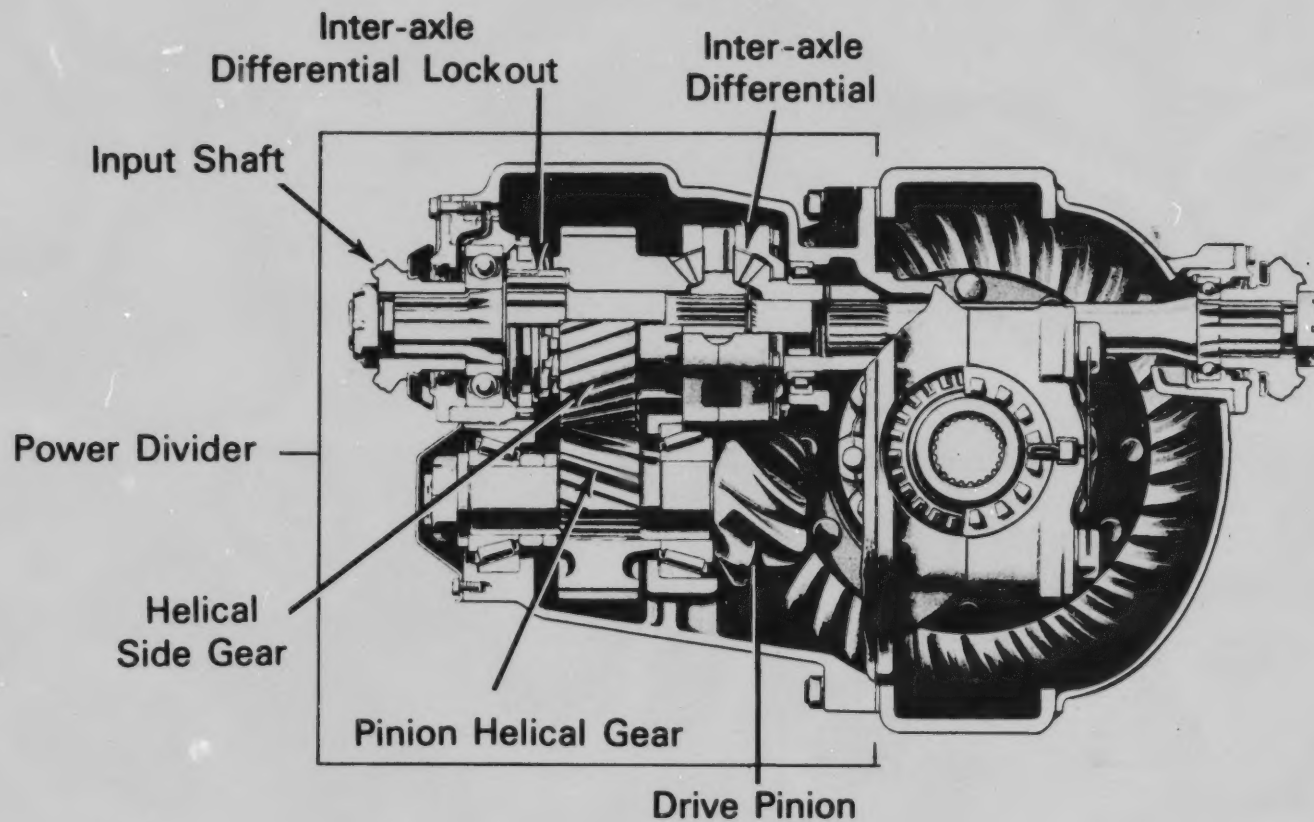
Parts of a Power Divider



Courtesy Transmission Division, Eaton Corporation

Parts of a Power Divider

(Continued)

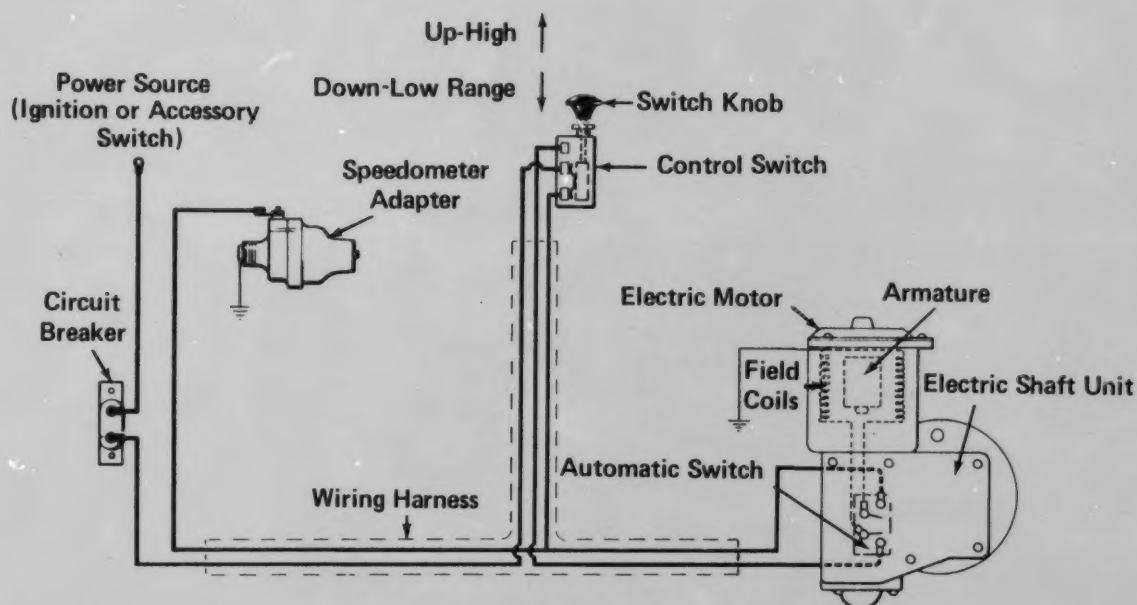


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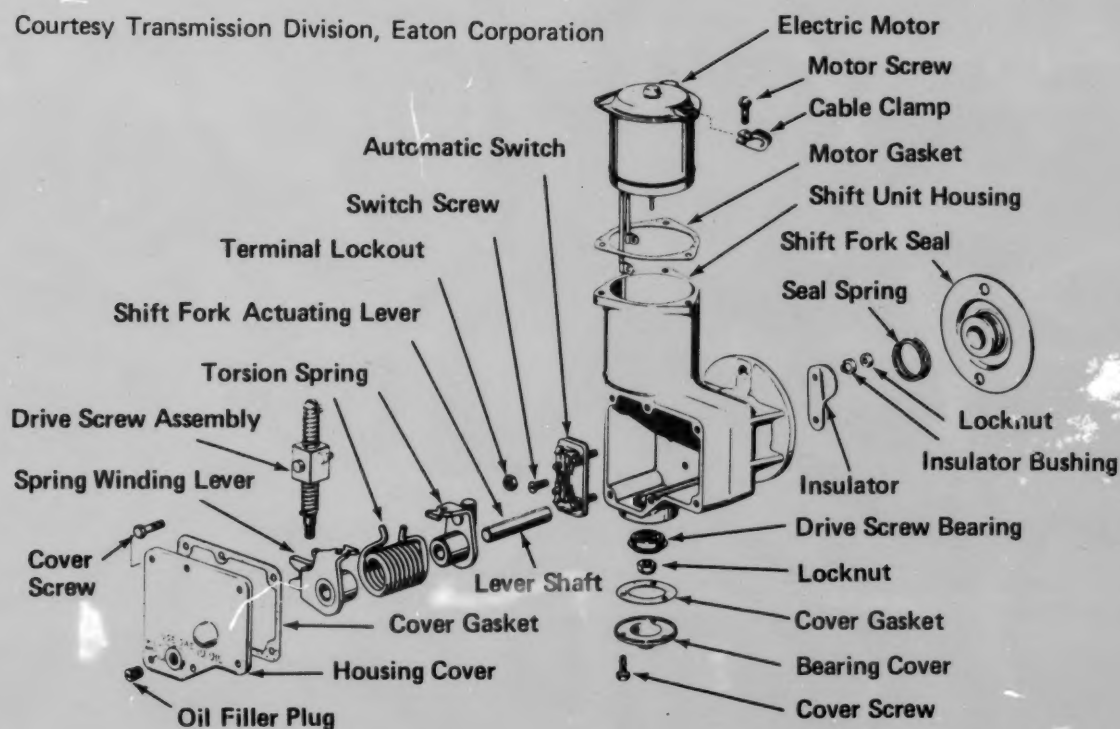
597

Courtesy Rockwell International

Electric Shift System

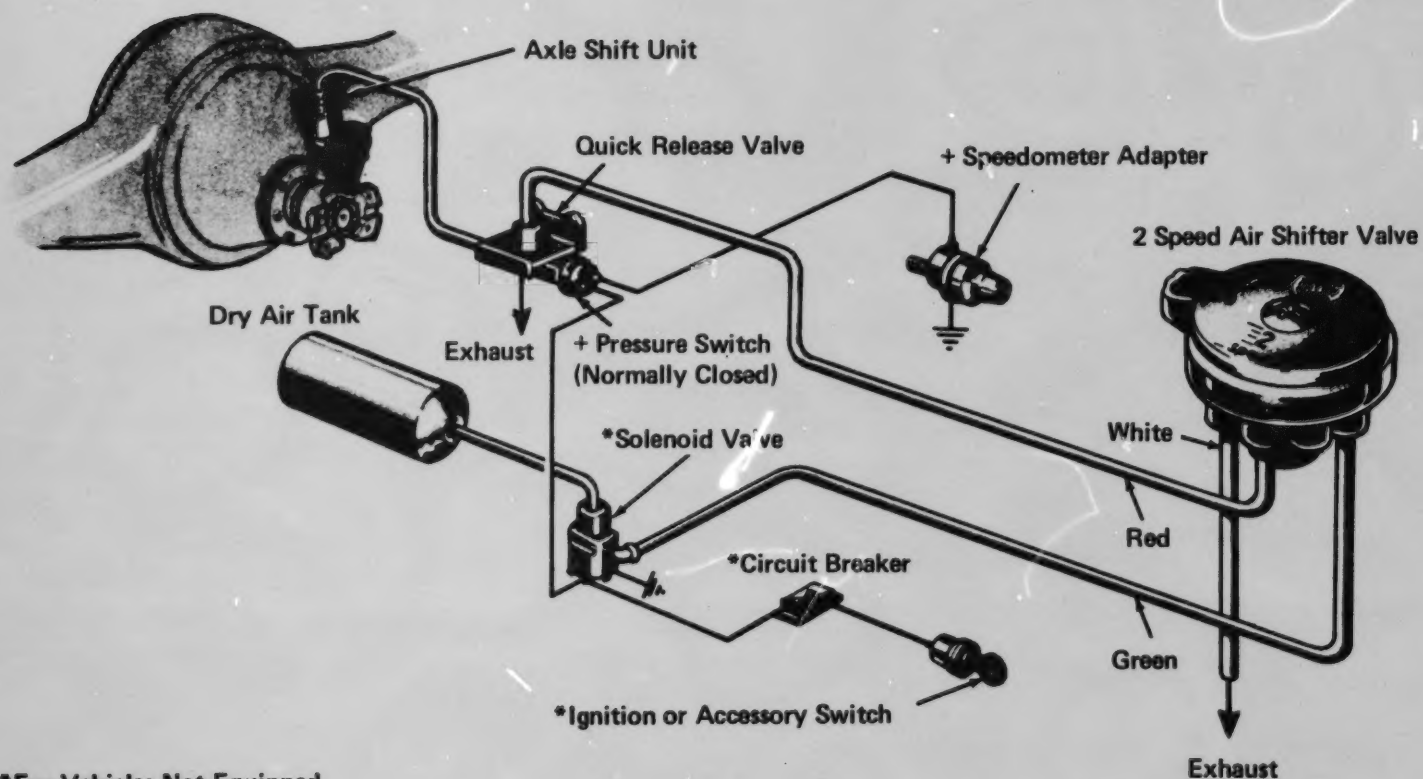


Courtesy Transmission Division, Eaton Corporation



2-Speed Single Axle Straight-Air Shift System

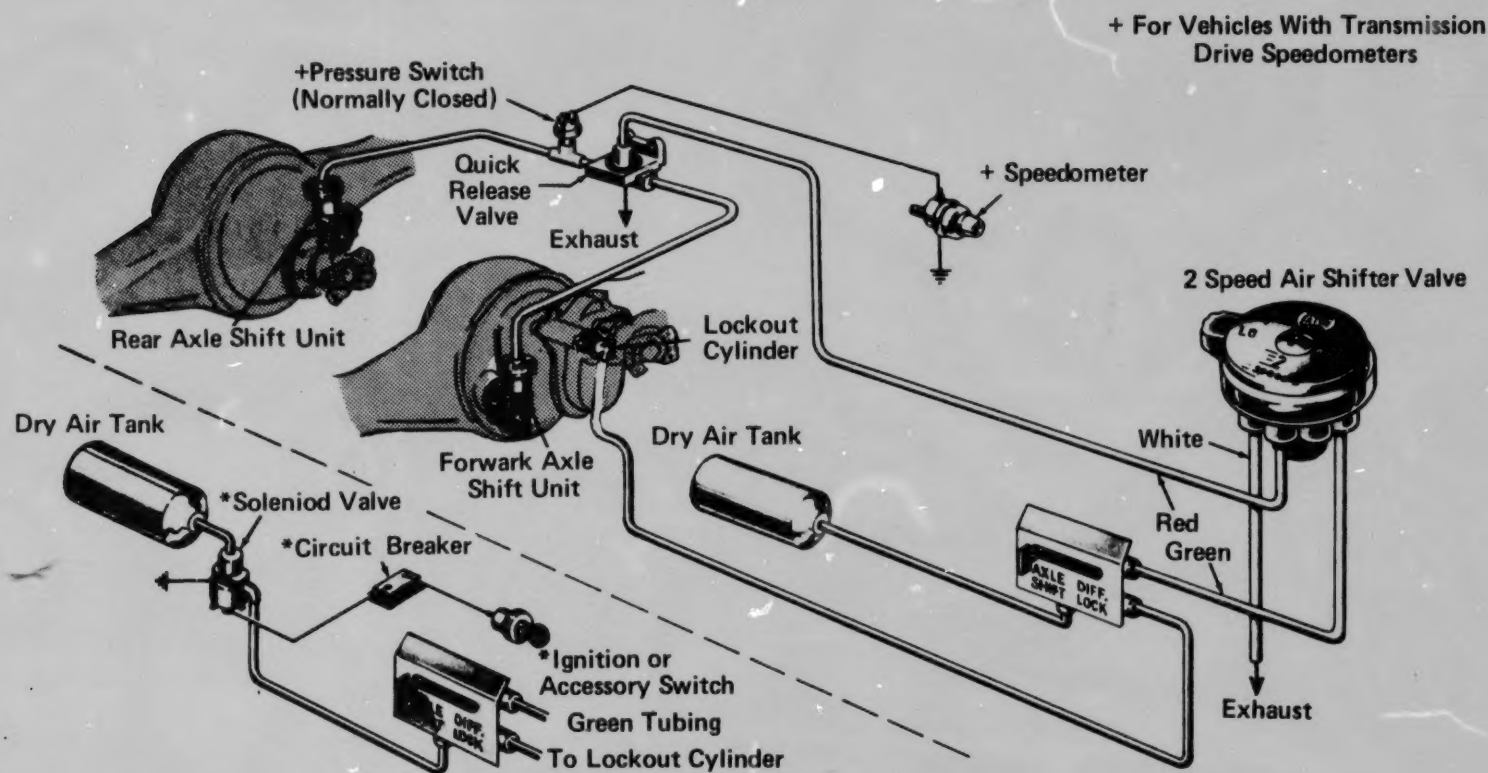
+ For Vehicles With Transmission
Drive Speedometers



*For Vehicles Not Equipped
With Automatic Safety Brakes

Courtesy Transmission Division, Eaton Corporation

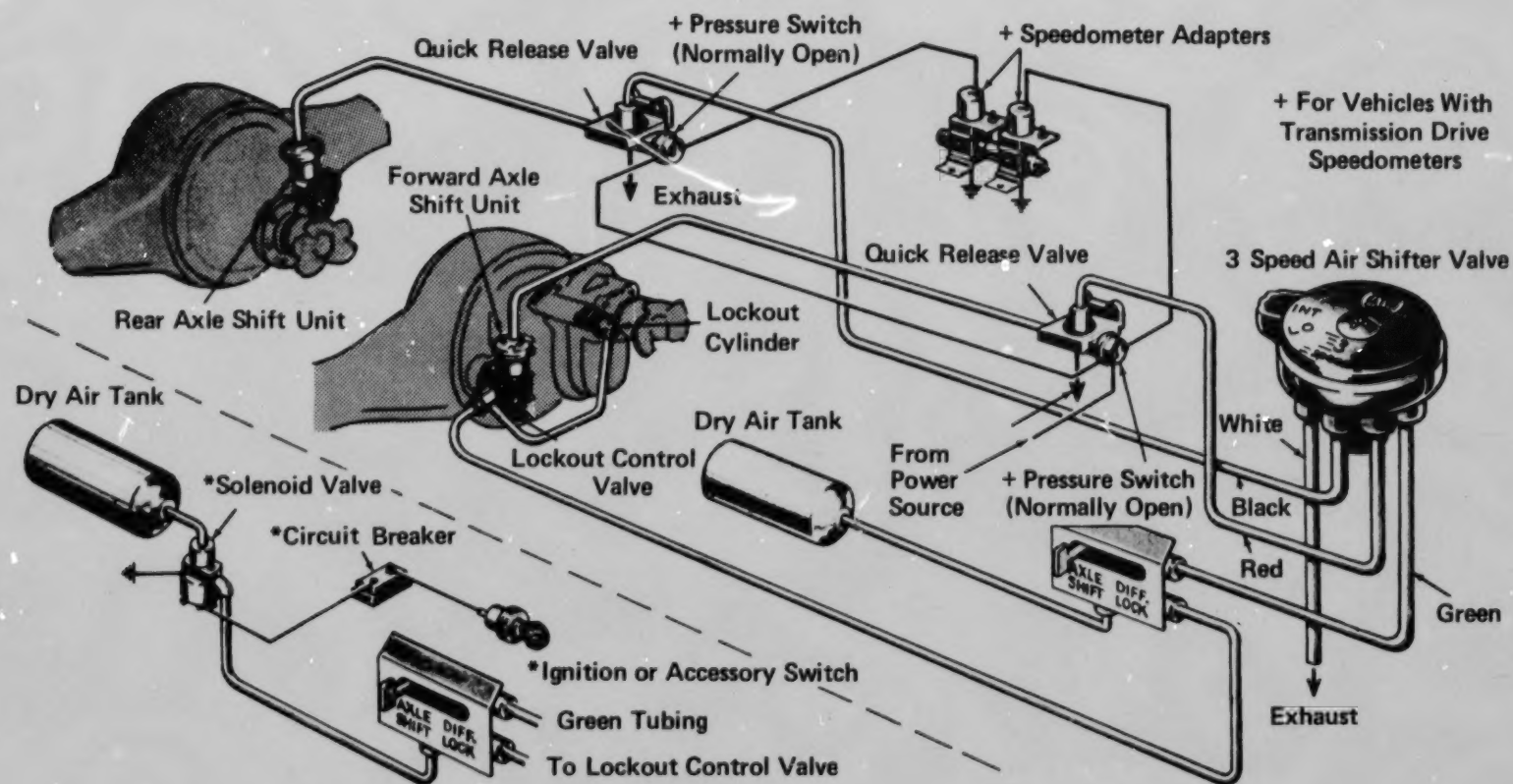
2-Speed Tandem Axle Straight-Air Shift System



*For Vehicles Not Equipped
With Automatic Safety Brakes

Courtesy Transmission Division, Eaton Corporation

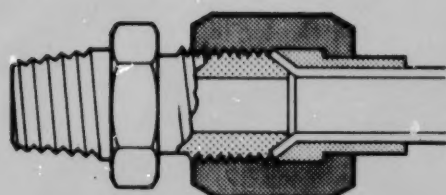
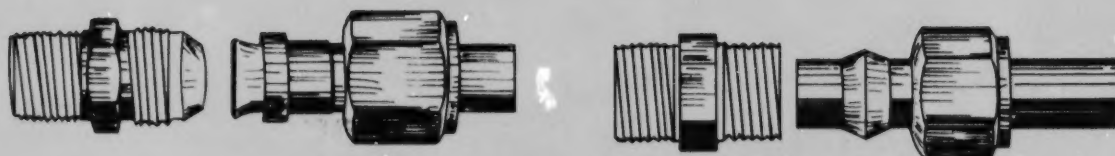
3-Speed Tandem Axle Straight-Air Shift System



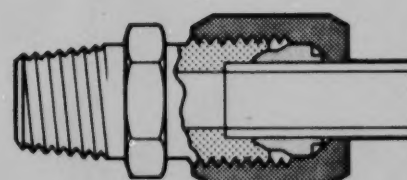
***For Vehicles Not Equipped With Automatic Safety Brakes**

Courtesy Transmission Division, Eaton Corporation

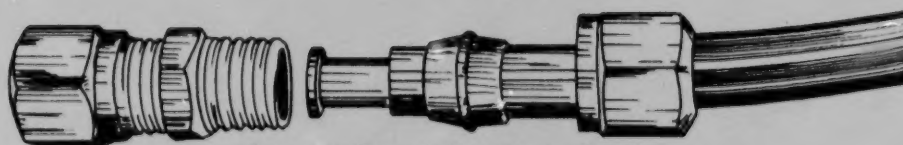
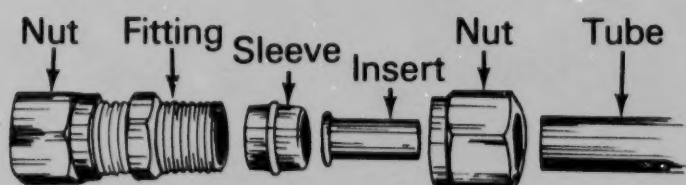
Types of Air Line Fittings



Flared Type



Compression Type



Insert Partially Installed
Nylon Air Line Assembly

DIFFERENTIALS AND FINAL DRIVES UNIT VII

JOB SHEET #1--REMOVE A DIFFERENTIAL ASSEMBLY

- I. Tools and equipment
 - A. Basic hand tools
 - B. Floor jack
 - C. Jack stands
 - D. Deep socket set, 1/2" drive
 - E. Differential jack
 - F. Drain pan
 - G. Drop light
 - H. Creeper
 - I. Safety glasses

- II. Procedure

(NOTE: This procedure will cover the straight axle drives, pinion drives, power dividers, differential locks, 2 and 3 speed axles and planetary drives.)

- A. Remove plug from bottom of axle housing and drain lubricant
- B. Remove the axle shaft stud nuts, lock-washers, and tapered dowels

(NOTE: To loosen axle shaft from the tapered dowels, hold a 1 1/2 inch diameter brass drift against the center of the axle shaft head; strike the drift sharply with a 5 to 6 pound hammer or sledge.)

(CAUTION: Check service manual; some manufacturers do not recommend this.)

- C. Remove the axle shaft from the drive unit and housing
- D. Remove drive line from pinion yoke and slide other end out of slip joint

(NOTE: Mark drive line with center punch before removing.)

- E. Place drive line out of work area
- F. Disconnect the electrical terminals or air hoses from shifting mechanisms if it is a differential with a 2-speed shifting mechanism; on tandem drive axles, disconnect the air hoses to the power divider shifting mechanism

JOB SHEET #1

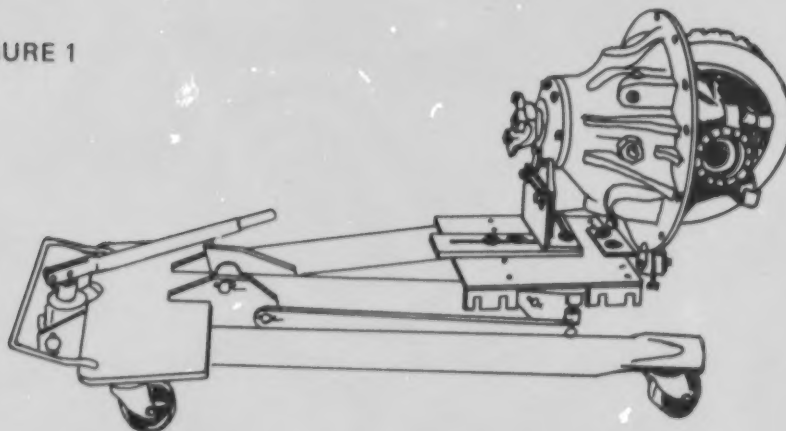
- G. Remove carrier to housing stud nuts

(CAUTION: Loosen two top nuts but leave on studs to prevent carrier from falling.)

- H. Break carrier loose from housing with a rawhide mallet

- I. Place differential jack under carrier (Figure 1)

FIGURE 1



- J. Remove top nuts and lock washers and work carrier free

(CAUTION: Keep to one side of differential while removing.)

- K. Use a small pinch bar to straighten carrier in housing bore

(NOTE: The end must be rounded to prevent indenting the carrier flange.)

- L. Bring differential straight out of carrier bore

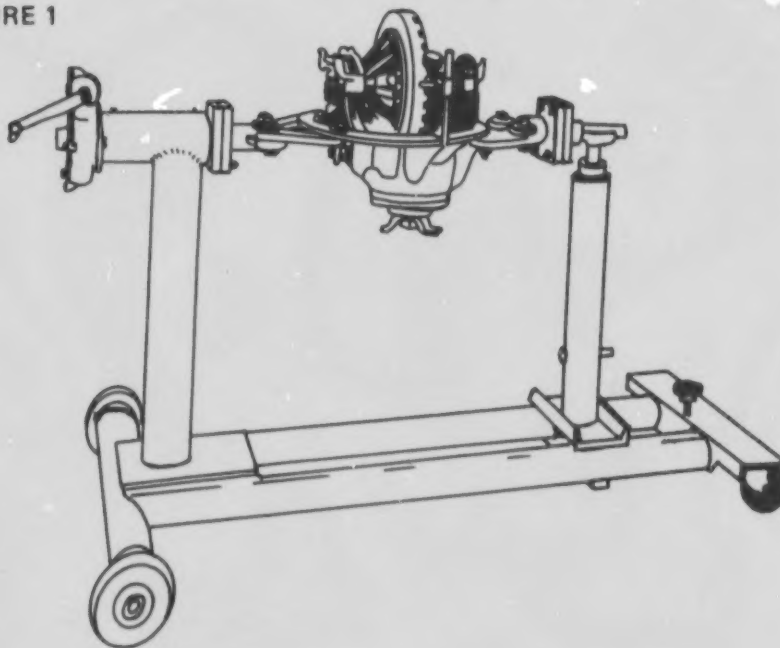
- M. Lower differential to floor and roll out from under vehicle

DIFFERENTIALS AND FINAL DRIVES UNIT VII

JOB SHEET #2--DISASSEMBLE A DIFFERENTIAL CASE AND GEAR ASSEMBLY.

- I. Tools and equipment
 - A. Basic hand tools
 - B. Carrier repair stand
 - C. Socket set, 3/4" drive
 - D. Socket set, 1/2" drive
 - E. Pry bar
 - F. Drive pinion flange puller
 - G. Safety glasses
- II. Procedure
 - A. Position the carrier on a differential carrier repair stand (Figure 1)

FIGURE 1



(NOTE: Procedure and illustrations courtesy Transmission Division, Eaton Corporation.)

JOB SHEET #2

- B. Mark differential bearing caps and carrier with a center punch for correct location in reassembly (Figure 2)

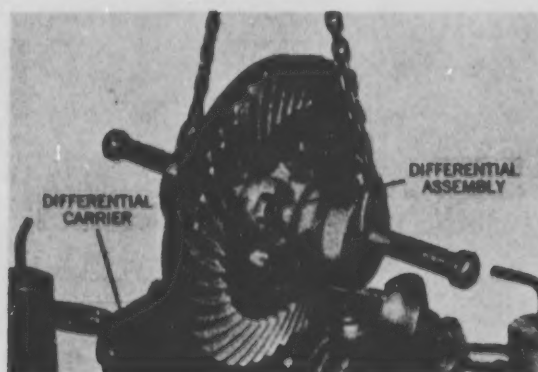
FIGURE 2



- C. Cut lockwires, then remove cap screws, differential bearing caps, and adjusters
- D. Lift out the differential and gear assembly (Figure 3)

(NOTE: On some differentials you will have to tilt ring gear away from pinion.)

FIGURE 3

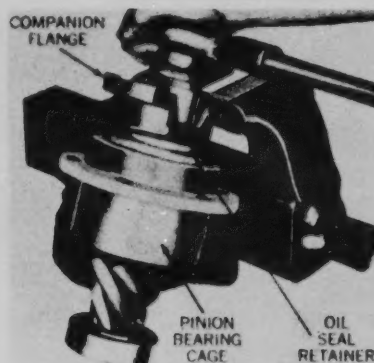


JOB SHEET #2

- E. Remove pinion flange or yoke shaft nut and washer (Figure 4)

(NOTE: There are different methods in removing nut and washer so check with manufacturer's specifications.)

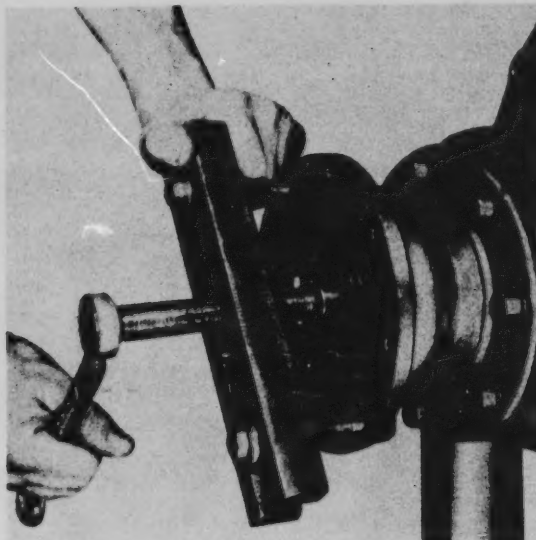
FIGURE 4



- F. Remove pinion flange or yoke with a suitable puller (Figure 5)

(NOTE: Driving the flange off will cause excessive runout.)

FIGURE 5



Courtesy Rockwell International

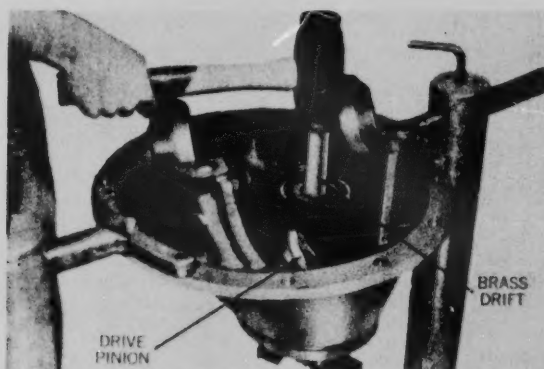
JOB SHEET #2

- G. Remove pinion cage stud nuts or capscrews
- H. Remove bearing cover and oil seal assembly
- I. Remove bearing cage (Figure 6)

(NOTE: Some manufacturer's provide puller holes and other manufacturers recommend driving the bearing cage out with a brass drift. Check with manufacturer's specifications before removing.)

(CAUTION: Note size and number of shims under bearing cage flange for easier adjustment during reassembly and wire shims together when removed.)

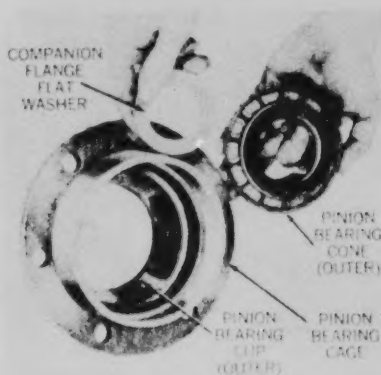
FIGURE 6



(CAUTION: The use of a pry bar will damage the shims.)

- J. Press drive pinion shaft out of bearing cage
- K. Remove outer bearing from cage (Figure 7)

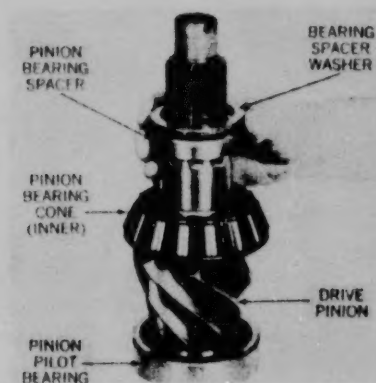
FIGURE 7



JOB SHEET #2

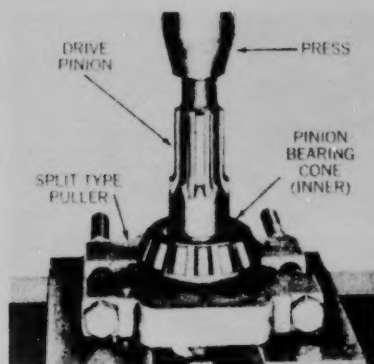
- L. Remove bearing spacer washer and spacer from drive pinion (Figure 8)

FIGURE 8



- M. Remove inner bearing cone and pilot bearing from drive pinion, using suitable pullers (Figure 9)

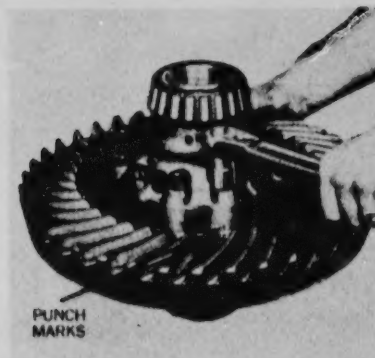
FIGURE 9



JOB SHEET #2

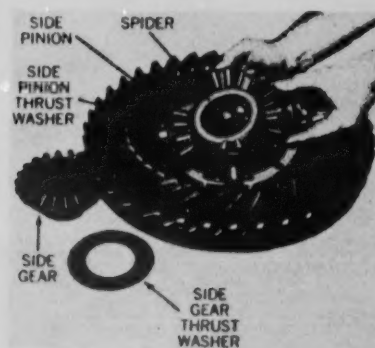
N. Punch mark differential cases for correct location in reassembly (Figure 10)

FIGURE 10



- O. Cut lockwire, then remove cap screws, nuts and bolts (Figure 10)
- P. Remove plain differential case (Figure 10)
- Q. Remove right-hand side gear and thrust washer, then lift out differential spider, side pinion, and thrust washer assembly (Figure 11)

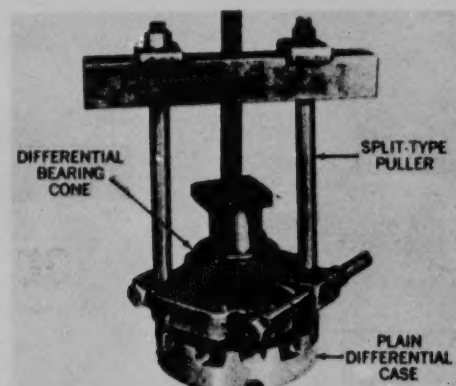
FIGURE 11



JOB SHEET #2

- R. Remove left-hand side gear and thrust washer from flanged differential case (Figure 11)
- S. Remove bearing cones from differential cases with a split-type puller (Figure 12)

FIGURE 12

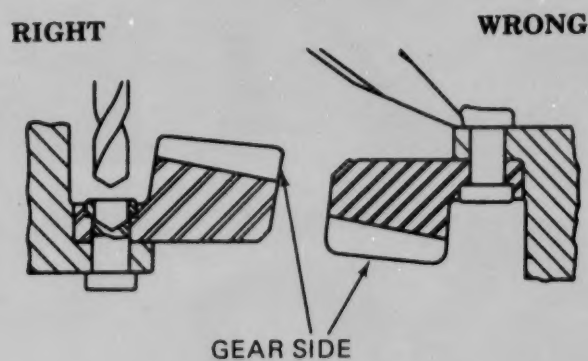


- T. Remove ring gear from flanged differential case (Figure 13)

(NOTE: Carefully center-punch rivets in center of head. Use drill 1/32" smaller than body of rivet to drill through head from gear side. Press out rivet.)

(CAUTION: Do not chisel out rivets.)

FIGURE 13



DIFFERENTIALS AND FINAL DRIVES UNIT VII

JOB SHEET #3--CLEAN AND INSPECT A DIFFERENTIAL CASE AND GEAR ASSEMBLY

- I. Tools and equipment
 - A. Basic hand tools
 - B. Solvent container
 - C. Solvent
 - D. Parts cleaning brush
 - E. Safety glasses
- II. Procedure
 - A. Wash parts having ground and polished surfaces such as gears, shafts, and bearings should be cleaned in a suitable solvent
(NOTE: Gasoline should be avoided.)
 - B. Do not steam clean assembled drive units after they have been removed from the housing
(NOTE: Water will be trapped in the cored passage of the castings and in the close clearances between parts as well as on the parts.)
 - C. Clean rough parts such as differential carrier castings and cast brackets in hot solution tanks with mild alkali solutions
(CAUTION: Exercise care to avoid skin rashes and inhalation of vapors when using alkali cleaners.)
 - D. Dry parts thoroughly after cleaning
 - E. Coat all parts that are to be immediately reassembled with light oil to prevent corrosion; parts should all be inspected, cleaned, and dried
 - F. Inspect all bearings, cups, and cones, including those not removed from parts of the drive unit
 - G. Inspect gears for wear or damage; gears which are worn, ridged, pitted or scored, should be replaced
(NOTE: Replace ring and pinion gears as a set.)

JOB SHEET #3

- H. Inspect the differential assembly for the following:
 - 1. Pitted, scored or worn thrust surfaces of differential case halves, thrust washers, spider trunnions, and differential gears
 - 2. Wear or damage to the differential pinion and side gear teeth
- I. Inspect axle shafts for signs of torsional fractures or other indication of impending failure
- J. Clean axle housing inside and outside thoroughly with solvent and blow dry with compressed air
(CAUTION: Wear safety glasses.)
- K. Inspect housing for cracks, loose studs, nicks, and burrs at machined surfaces

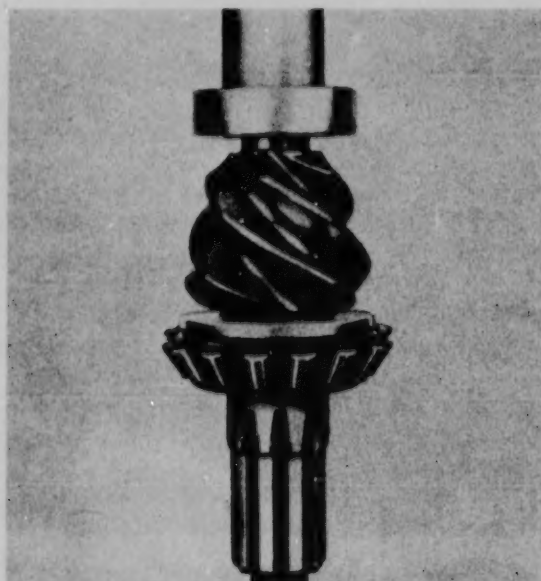
DIFFERENTIALS AND FINAL DRIVES UNIT VII

JOB SHEET #4-ADJUST DRIVE PINION BEARING PRELOAD

- I. Tools and equipment
 - A. Basic hand tools
 - B. Hydraulic press
 - C. Torque wrench, foot pound
 - D. Roll of soft wire
 - E. Inch pound spring scale
 - F. Safety glasses
- II. Procedure
 - A. Press new bearing cup firmly against pinion bearing cage shoulders
 - B. Lubricate bearings and cups with light machine oil
 - C. Press pilot bearing firmly against the pinion shoulders with a suitable sleeve that will bear only on bearing inner race (Figure 1)

(NOTE: Some pilot bearings require a snap ring to hold bearing.)

FIGURE 1

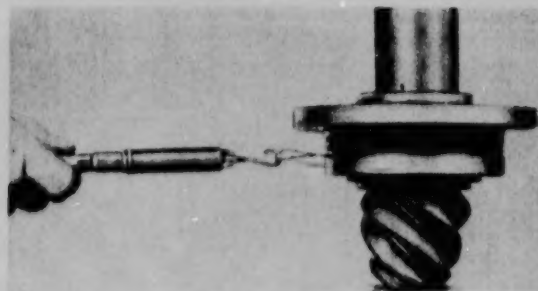


(NOTE: Procedure and illustrations courtesy Rockwell International.)

JOB SHEET #4

- D. Install pinion and bearing assembly into bearing cage and slide spacer onto pinion shaft
- E. Press front bearing firmly against spacer
- F. Rotate cage several revolutions to assure normal bearing contact
- G. Check bearing preload while in press under pressure by wrapping soft wire around cage and pulling on horizontal line with pound scale (Figure 2)

FIGURE 2



- H. Tighten the pinion nut to the correct torque and check preload if a press is not available
- I. Check with manufacturer's specifications for torque for pinion nut and correct preload settings and beware of possible conversion factors (Figure 3)

(NOTE: Example of some pressures and torques for checking pinion bearing preload are as follows:)

FIGURE 3

PINION SHAFT THREAD SIZE	PRESSURE REQUIRED TO OBTAIN CORRECT PRE-LOAD	NUT TORQUE REQUIRED (FOR FASTENERS USING LOCKWIRE OR COTTER PINS) TO OBTAIN CORRECT PRE-LOAD	NUT TORQUE REQUIRED (FOR FASTENERS NOT USING LOCKWIRE OR COTTER PINS) TO OBTAIN CORRECT PRE-LOAD
7/8"—20	6 tons	175- 200 lb. ft.	200- 275 lb. ft.
7/8"—20	6 tons (elastic nut)	200- 275 lb. ft.	—
1"—20	6 tons	300- 400 lb. ft.	300- 400 lb. ft.
1 1/4"—12	11 tons	—	700- 900 lb. ft.
1 1/4"—18	11 tons	700- 900 lb. ft.	700- 900 lb. ft.
1 1/2"—12	14 tons	800-1100 lb. ft.	800-1100 lb. ft.
1 1/2"—18	14 tons	800-1100 lb. ft.	900-1200 lb. ft.
1 3/4"—12	14 tons	—	1000-1300 lb. ft.
2"—12	14 tons	800-1100 lb. ft.	—

JOB SHEET #4

- J. Check rotating torque; if it is not within specifications, use a thinner spacer to increase preload or a thicker spacer to decrease preload
- K. Torque pinion yoke onto pinion shaft and recheck preload if the preload was set in the press
- L. Use torque wrench method, if needed, to check preload; some pinion bearings can be checked with this method
 - 1. Place drive pinion in vise
 - 2. Rotate bearing cage by hand a few times
 - 3. Then rotate bearing cage with torque wrench and note reading
 - 4. Check with manufacturer's specifications for correct preload
 - 5. Use thinner spacer to increase preload and thicker spacer to decrease preload
- M. Clamp bearing carrier in vise and use inch-pound torque wrench on pinion nut and set preload to manufacturer's specifications

(CAUTION: Do not use shim stock to increase thickness of spacer; always use correct size spacer.)

DIFFERENTIALS AND FINAL DRIVES UNIT VII

JOB SHEET #5--REASSEMBLE A DIFFERENTIAL CASE AND GEAR ASSEMBLY

(NOTE: Procedure and illustrations courtesy Rockwell International.)

- I. Tools and equipment
 - A. Basic hand tools
 - B. Socket set, 3/4" drive
 - C. Socket set, 1/2" drive
 - D. Torque wrench, foot pound
 - E. Drop light
 - F. Shop towels
 - G. Safety glasses
 - H. Differential repair stand
 - I. Ring gear rivet fixture for press
- II. Procedure
 - A. Make sure that differential case and gear assembly parts are clean
 - B. Install same number and size shims that were removed in disassembly onto assembled pinion bearing cage

(CAUTION: Locate thin shims on both sides for maximum sealing ability.)
 - C. Position pinion and cage assembly over studs and tap into position with soft mallet

(NOTE: If there are no studs on differential case, you can make studs out of a 5" long bolt and cut head of bolt off.)
 - D. Install lock washers and stud nuts or capscrews, and tighten to manufacturer's torque specifications
 - E. Rivet the ring gear to the flange case half with new rivets

(NOTE: Rivets should not be heated, but always upset cold.)

JOB SHEET #5

F. Rivet ring gear and case together to manufacturer's specifications (Figure 1)

FIGURE 1	DIAMETER OF RIVET	TONNAGE REQUIRED
	$\frac{7}{16}$ "	22
	$\frac{1}{2}$ "	30
	$\frac{9}{16}$ "	38
	$\frac{5}{8}$ "	45

1. Differential case and gear bolts are also available for service replacement of rivets

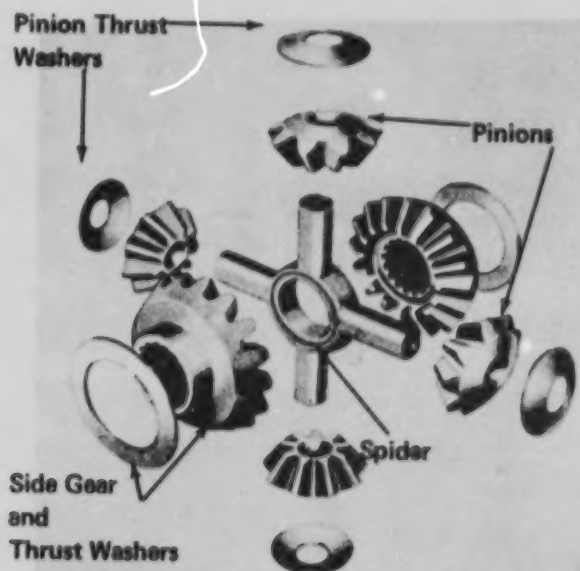
2. Torque bolts (if used) to manufacturer's specifications

G. Lubricate differential case inner walls and all component parts with axle lubricant

H. Position thrust washer and side gear in gear case half

I. Place spider with pinions and thrust washers in position (Figure 2)

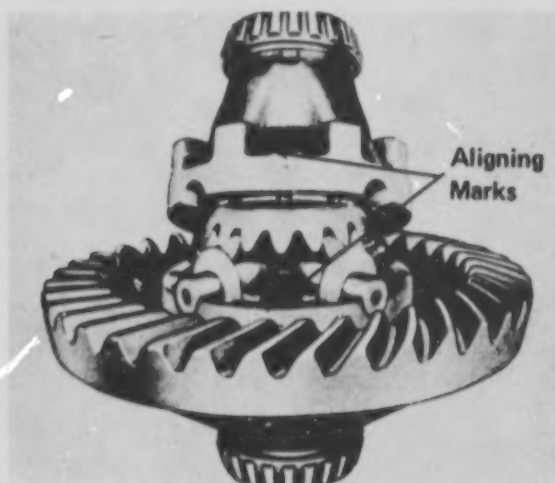
FIGURE 2



JOB SHEET #5

- J. Install second side gear and thrust washer
- K. Align mating marks, position plain case half and draw assembly together with four equally spaced cap screws (Figure 3)

FIGURE 3



- L. Check assembly for free rotation of differential gears
- M. Install remaining capscrews and tighten to correct torque and lockwire if used
- N. Press differential bearings squarely and firmly onto differential case halves with suitable sleeve
- O. Place gear assembly into differential case (Figure 4)

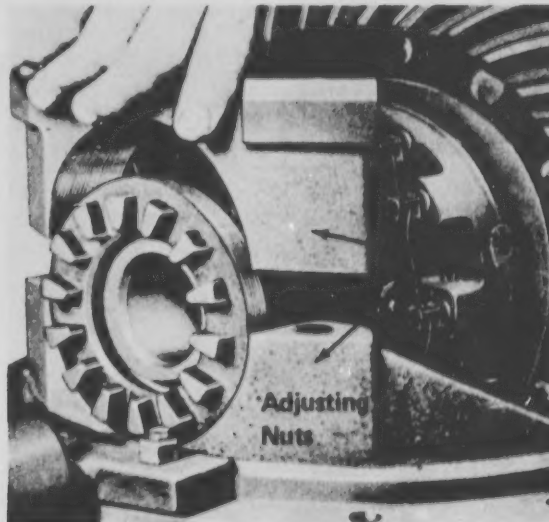
FIGURE 4



JOB SHEET #5

- P. Place cup over bearings and position assembly in carrier housing
- Q. Insert bearing adjusting nuts and turn hand-tight against bearing cups
- R. Install bearing caps in the correct location as marked and tap lightly into position (Figure 5)

FIGURE 5



(CAUTION: If bearing caps do not position properly, adjusting nuts might be cross threaded. Remove caps and reposition the adjusting nuts. Forcing caps into position will result in irreparable damage to the carrier housing or bearing caps.)

- S. Install carrier leg capscrews and tighten to required torque. If carrier leg capscrews are drilled or castellated, safety wire **after** final adjustments are made

(NOTE: For differential bearing pre-load, gear backlash, and tooth contact pattern go to Job Sheet #6.)

DIFFERENTIALS AND FINAL DRIVES UNIT VII

JOB SHEET #6--ADJUST DIFFERENTIAL BEARING PRELOAD, CHECK GEAR BACKLASH AND TOOTH CONTACT PATTERN

(NOTE: Procedure and illustrations courtesy Rockwell International.)

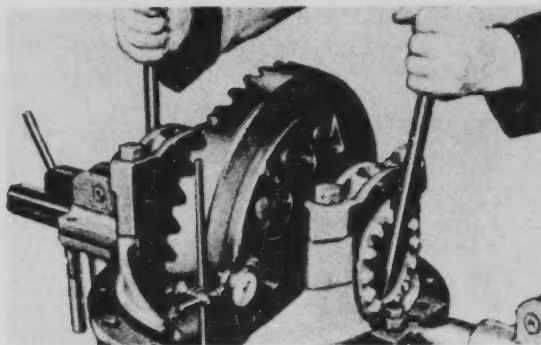
I. Tools and equipment

- A. Basic hand tools
- B. Pry bar
- C. Dial indicator
- D. Small container of marking compound
- E. Torque wrench
- F. Shop towels
- G. Safety glasses

II. Procedure

- A. Position differential case and gear assembly into a differential repair stand
- B. Check bearing preload
 1. Using a dial indicator at backface of ring gear, loosen the bearing adjusting nut on the side opposite ring gear only enough to notice end play on the dial indicator (Figure 1)

FIGURE 1



2. Tighten the same adjusting nut only enough to obtain .000 end play. Rotate ring gear to check ring gear for runout, if runout exceeds .008", remove differential and check for cause

(NOTE: Check to manufacturer's specifications for runout on differential being worked on.)

JOB SHEET #6

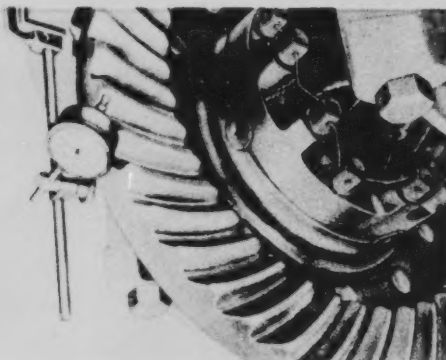
3. Tighten adjusting nuts one notch each from .000" end play to preload differential bearing

(NOTE: Check service manual for manufacturer's pre-load specifications.)

C. Check gear backlash

1. Place dial indicator on tooth side of ring gear (Figure 2)

FIGURE 2



2. Hold pinion yoke with one hand and rock ring gear back and forth between tooth to tooth clearance
3. While rocking ring gear back and forth, check dial indicator to see if backlash is within specifications

(NOTE: Set backlash to manufacturer's specifications.)

4. Adjust backlash by moving the ring only
5. This is done by backing off one adjusting ring and advancing the opposite ring the same amount

JOB SHEET #6

D. Check tooth contact pattern (Figure 3)

1. Apply the pattern paste to both sides of the ring gear teeth

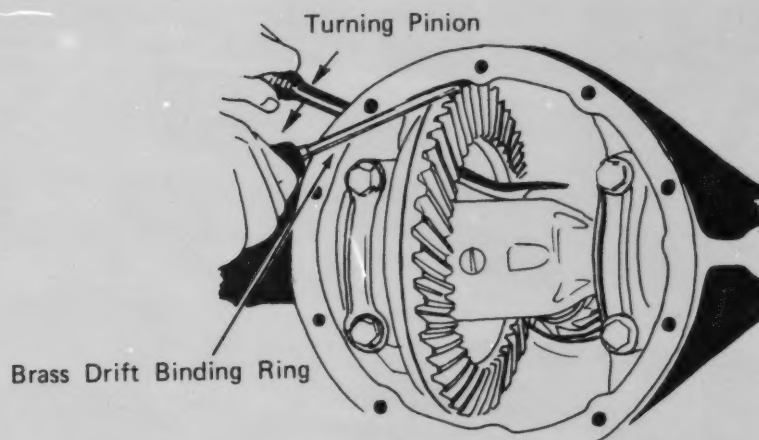
FIGURE 3



(NOTE: As a rule, coating about twelve teeth is sufficient for checking purposes.)

2. Turn the drive pinion while holding on to the ring gear (Figure 4)

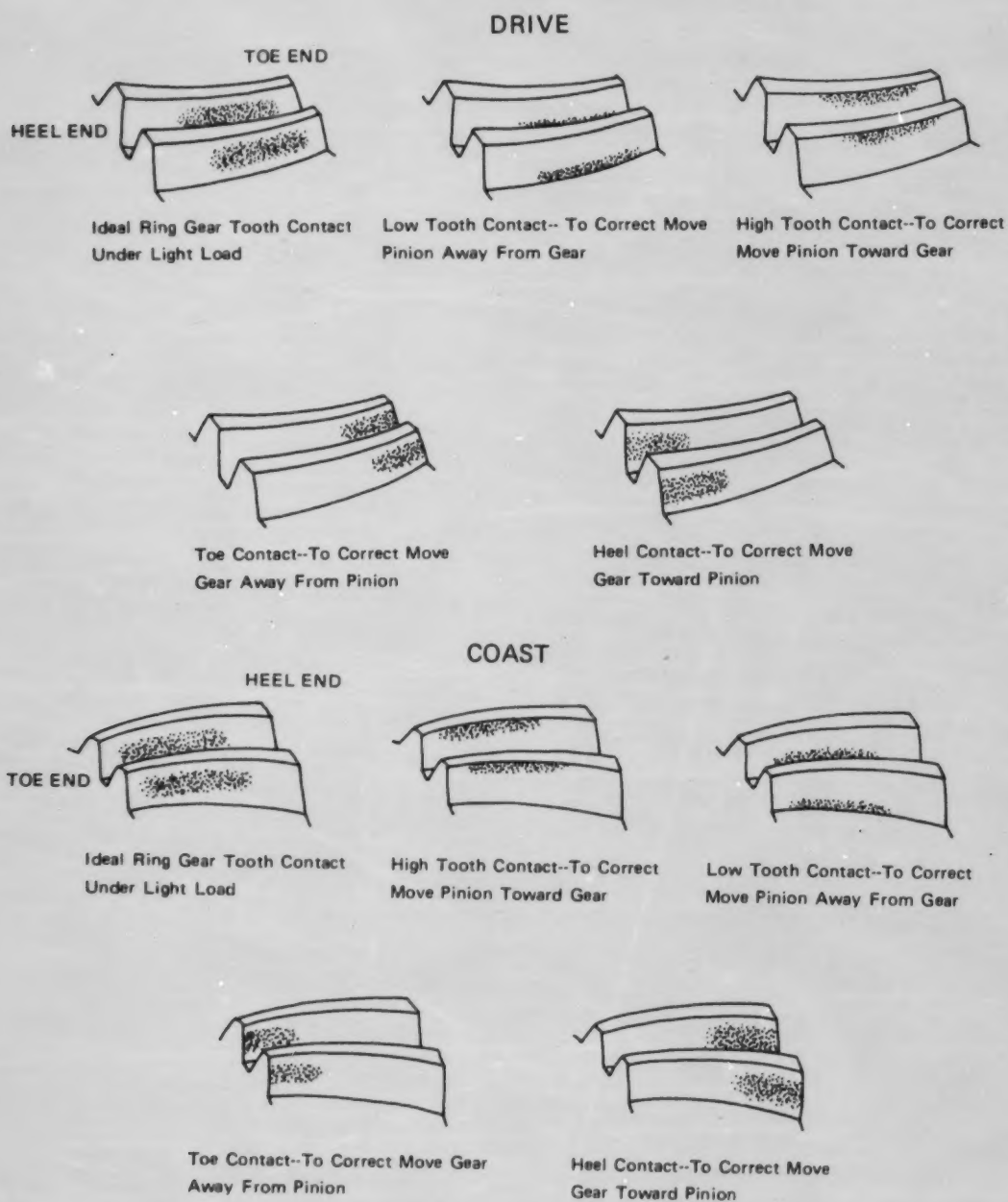
FIGURE 4



JOB SHEET #6

3. Compare the ring gear tooth pattern with the patterns in Figure 5

FIGURE 5



JOB SHEET #6

- E. Install the thrust screw or block (if used)
- F. Torque all capscrews that need to be tightened to manufacturer's specifications
- G. Tie capscrews with lockwire (if used)

DIFFERENTIALS AND FINAL DRIVES UNIT VII

JOB SHEET #7--INSTALL DIFFERENTIAL ASSEMBLY IN DIFFERENTIAL HOUSING

I. Tools and equipment

- A. Basic hand tools
- B. Floor jack
- C. Jack stands
- D. Deep socket set, 1/2" drive
- E. Differential jack
- F. Drop light
- G. Creeper
- H. Appropriate service manual
- I. Safety glasses

II. Procedure

- A. Make sure old gasket is cleaned off differential case flange and housing flange
- B. Put differential on differential jack, and secure on jack, then roll under vehicle
- C. Install new drive unit and housing gasket on housing stud
(NOTE: Check service manual; some housings require sealant only.)
- D. Start carrier into housing and start four nuts and flat washers equally spaced and tighten alternately to draw the carrier squarely into axle housing
(CAUTION: Driving carrier into housing with a steel hammer will damage carrier flange and cause oil leakage.)
- E. Remove nuts and flat washers and install lock washers and stud nuts or capscrews, and tighten to correct torque
- F. Clean old gasket off of axle flange and axle hub, and install new gasket before installing axle shaft

(NOTE: Check with manufacturer's specifications for torque for stud nuts on axle.)

JOB SHEET #7

- G. Tighten drain plug in bottom of housing, and remove fill plug and fill carrier with lubricant

(NOTE: Check with manufacturer's specifications for type of lubricant to use.)

- H. Install drive line to aligning marks and tighten securely
- I. Check vent on differential housing to make sure it is free of dirt

DIFFERENTIALS AND FINAL DRIVES UNIT VII

JOB SHEET #8-REMOVE, REPAIR, AND REASSEMBLE A DIFFERENTIAL CARRIER AND POWER DIVIDER ASSEMBLY

(NOTE: Procedure and illustrations courtesy Transmission Division, Eaton Corporation.)

I. Tools and equipment

- A. Basic hand tools
- B. Clean shop towels
- C. Press
- D. Repair stand
- E. Hoist and chain sling
- F. Output shaft oil seal puller
- G. Bearing puller
- H. Inch-pound, 100 foot-pound, and 100 foot-pound torque wrenches
- I. Feeler gauge
- J. Sealant
- K. Dial indicator
- L. New carrier and cover gaskets
- M. Safety glasses

II. Procedure

(NOTE: The following procedure and illustrations are adapted from materials published and copyrighted 1977 by Eaton Corporation, and are reprinted with permission; this procedure is applicable to Eaton "D" series tandem drive axles, 30D, 34D, 38D, 42D, 50D, D340, D380, and D400 with input shaft tapered roller bearing; your instructor may modify this procedure to facilitate available equipment.)

- A. Remove and disassemble axle housing cover with the following procedure:
 - 1. Drain lubricant
 - 2. Disconnect propeller shafts at companion flanges and remove axle shafts
 - 3. Remove cotter pin, nut, flat washer, companion flange, and retainer washer from output shaft
 - 4. Remove cover to axle housing stud nuts and lockwashers
 - 5. Remove cover assembly and discard cover gasket

JOB SHEET #8

6. To disassemble axle housing cover, remove oil seal from output shaft opening, using suitable puller
7. Remove snapping from output shaft opening, then press rear bearing from axle housing cover

(NOTE: Rear bearing sleeve is mounted on the output shaft.)

- B. Remove differential carrier and power divider assembly from axle housing with the following procedure:

1. Disconnect lockout connections
2. If axle is 2-speed, remove shift unit to differential carrier nuts and flat washers
3. Disconnect electric wire or tubing as necessary to permit removal of shift unit
4. Remove carrier to axle housing stud nuts and lockwashers
5. Lift and pull differential carrier and power divider assembly out of axle housing

(CAUTION: The carrier and divider assembly are very heavy and must be lifted and moved with special care; the best way is to rig a chain sling and lift the entire assembly with a hoist that can safely transport it to the repair stand.)

- C. Stop at this point and have your instructor check and initial your procedure and safe practice

INSTRUCTOR CHECK: Procedure ☐ Safety ☐ Initials ☐

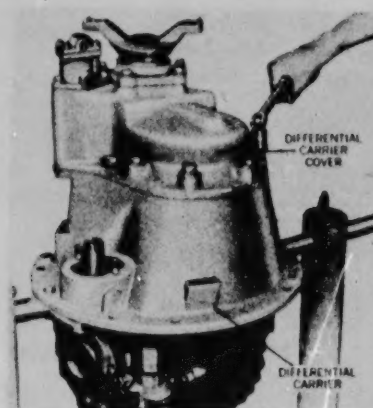
- D. Disassemble the differential carrier and power divider with the following procedure:

1. Make a preliminary inspection of units; if ring gear and drive pinion are satisfactory, check backlash and tooth contact pattern for easier adjustment at time of reassembly

JOB SHEET #8

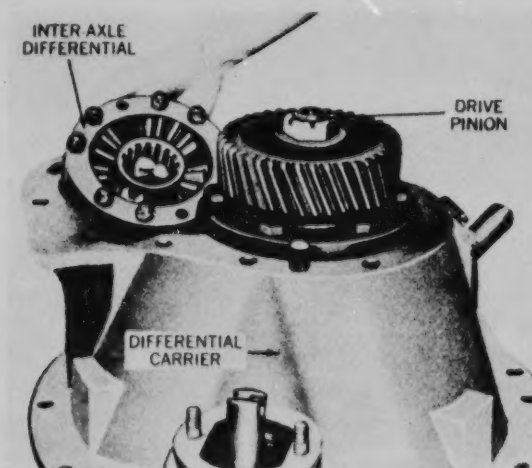
2. Remove carrier cover to differential carrier cap screws and lockwashers, then remove carrier cover assembly (Figure 1)

FIGURE 1



3. Lift inter-axle differential off output shaft side gear (Figure 2)

FIGURE 2



4. Before disassembling inter-axle differential, punch mark cases for correct position during reassembly
5. Remove locknuts and bolts
6. If lockwire is used, cut wire and remove nuts and bolts
7. Separate cases and remove thrust washers, side pinions, bushings, and spider

JOB SHEET #8

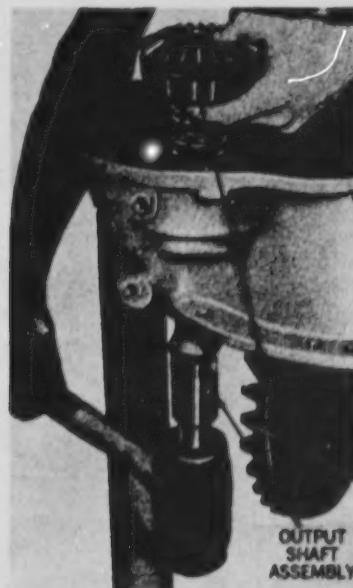
- E. Stop at this point and have your instructor check and initial your procedure and safe practice

INSTRUCTOR CHECK: Procedure ☐ Safety ☐ Initials ☐

- F. Remove and disassemble output shaft with the following procedure:

1. If output shaft holdout spring and thrust washer are used, remove and discard
2. Lift output shaft assembly from differential carrier, tapping at companion flange end of shaft (Figure 3)
3. Remove bearing cup from carrier (Figure 3)

FIGURE 3

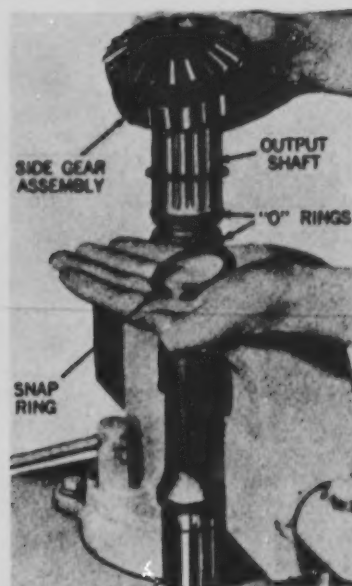


4. Disassemble output shaft by removing snapping, then lifting off side gear assembly (Figure 4)

JOB SHEET #8

5. Discard output shaft "O" rings (Figure 4)

FIGURE 4

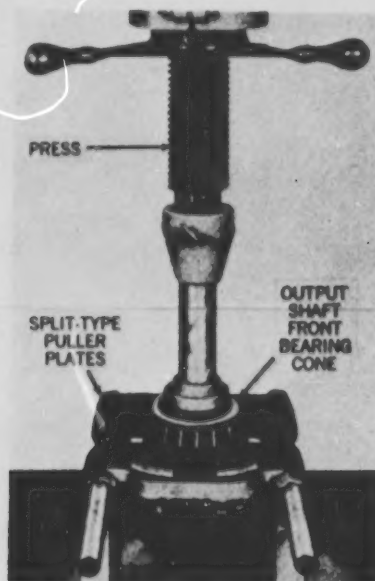


6. If replacement is necessary, remove bushing from bore of output shaft
7. Remove output shaft front bearing cone from side gear

JOB SHEET #8

8. Place side gear assembly in press with split-type puller plates under front bearing cone, then press side gear out of front bearing cone (Figure 5)

FIGURE 5



9. Remove and disassemble input shaft by removing snapping from input shaft, then lift off helical-side gear, helical-side gear thrust washer, and "D" washer (Figure 6)
10. If replacement is necessary, press bushings from bore of helical-side gear (Figure 6)

FIGURE 6



JOB SHEET #8

11. Remove cotter pin, nut, flat washer, and input companion flange from input shaft (Figure 7)

FIGURE 7



12. Remove input shaft bearing cover to differential carrier cover cap screws, then lift off bearing cover assembly and shims (Figure 8)

FIGURE 8

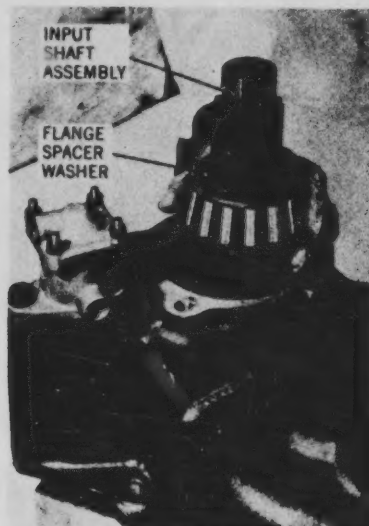


13. Note size and quantity of shims for easier adjustment during reassembly (Figure 8)
14. Remove oil seal and bearing cup from bearing cover (Figure 8)

JOB SHEET #8

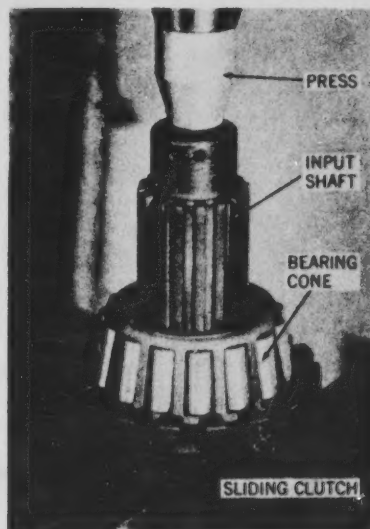
15. Lift input shaft assembly out of carrier cover, disengaging the shaft from the sliding clutch, and remove flange spacer washer (if used) from input shaft (Figure 9)

FIGURE 9



16. To remove bearing cone from input shaft, temporarily place sliding clutch on shaft, teeth toward the bearing cone, then press shaft out of cone (Figure 10)

FIGURE 10



JOB SHEET #8

- G. Stop at this point and have your instructor check and initial your procedure and safe practice

INSTRUCTOR CHECK: Procedure ☐ Safety ☐ Initials ☐

- H. Remove lockout (air-operated type) with the following procedure:

1. Remove nuts, lockwashers, and cover from shift cylinder body (Figure 11)
2. Remove nut and flat washer from push rod (Figure 11)
3. Remove cap screws, lockwashers, shift cylinder body assembly, gasket, and compression spring from carrier cover (Figure 11)
4. Remove and check strainer plate vent screens and felt for plugged condition, and clean or replace parts
5. Remove shift fork and push rod assembly, and input shaft sliding clutch from carrier cover (Figure 12)

FIGURE 11

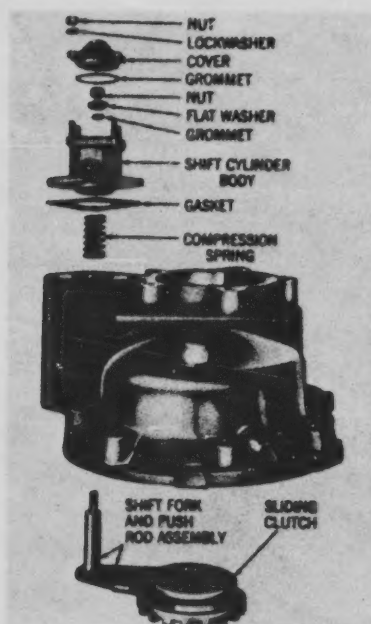


FIGURE 12



JOB SHEET #8

- I. Stop at this point and have your instructor check and initial your procedure and safe practice

INSTRUCTOR CHECK: Procedure ☐ Safety ☐ Initials ☐

- J. Remove cotter pin and loosen drive pinion helical gear nut before removing differential assembly

- K. Remove and disassemble axle differential by referring to appropriate service manual for Single Reduction, 2-Speed, or Planetary Double Reduction Axles

(NOTE: If oil distributor is used, be sure to remove pipe plug, spring, and distributor from carrier before attempting to remove differential.)

- L. Remove and disassemble drive pinion by referring to appropriate service manual for Single Reduction, 2-Speed, or Planetary Double Reduction Axles, except for the following variations:

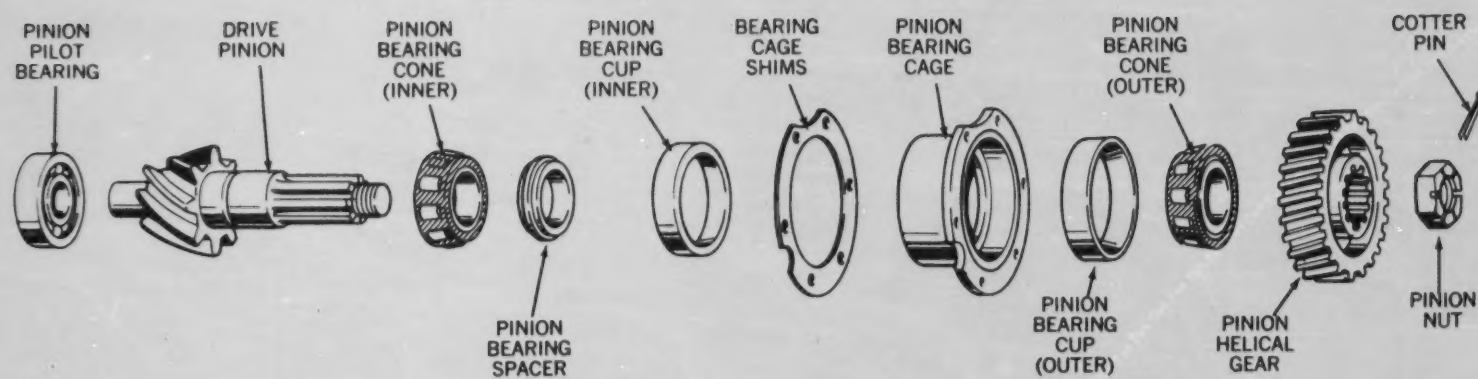
1. The drive pinions for the single drive axles are equipped with companion flanges; for this type installation, the pinion bearing cage cap screws are accessible to permit removal of pinion with flange assembled
2. The drive pinions for "D" Series Tandem Axle units are equipped with a helical gear, which must be removed to gain access to pinion bearing cage cap screws; therefore, to remove drive pinion, remove nut (previously loosened before differential removal)

(NOTE: See Figure 13 on following page for parts references for removal, disassembly, and assembly, and reinstallation of drive pinion.)

3. Mount bearing puller on helical gear, gripping gear with puller legs and placing puller screw against pinion, then pull gear off pinion
4. Remove pinion bearing cage cap screws, then remove drive pinion assembly

JOB SHEET #8

FIGURE 13



Exploded View of Drive Pinion

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JOB SHEET #8

- M. Stop at this point and have your instructor check and initial your procedure and safe practice

INSTRUCTOR CHECK: Procedure ☐ Safety ☐ Initials ☐

- N. Assemble and reinstall drive pinion by referring to appropriate service manual for Single Reduction, 2-Speed, or Planetary Double Reduction Axles, except for the following variations:

1. The drive pinions or the standard axle units are equipped with companion flanges; the pinion bearing cage cap screws are accessible to permit installation of pinion with companion flange installed
2. The drive pinions for the "D" Series Tandem Axle units are equipped with a helical gear (refer to Figure 13), and the bearing cap screws cannot be reinstalled with helical gear attached to drive pinion
3. Install pinion in "D" Series Tandem Axle units with helical gear removed
4. After pinion is installed, then place helical gear on pinion
5. Install and tighten pinion nut to correct torque, then install cotter pin

- O. Assemble and reinstall axle differential by referring to appropriate service manual for Single Reduction, 2-Speed, or Planetary Double Reduction Axles

(NOTE: If oil distributor is used, be sure to install oil distributor, spring, and pipe plug before installing differential carrier cover.)

- P. Stop at this point and have your instructor check and initial your procedure and safe practice

INSTRUCTOR CHECK: Procedure ☐ Safety ☐ Initials ☐

- Q. Assemble and reinstall output shaft with the following procedure:

1. If removed, press front bearing cup in differential carrier and bushing in bore of output shaft

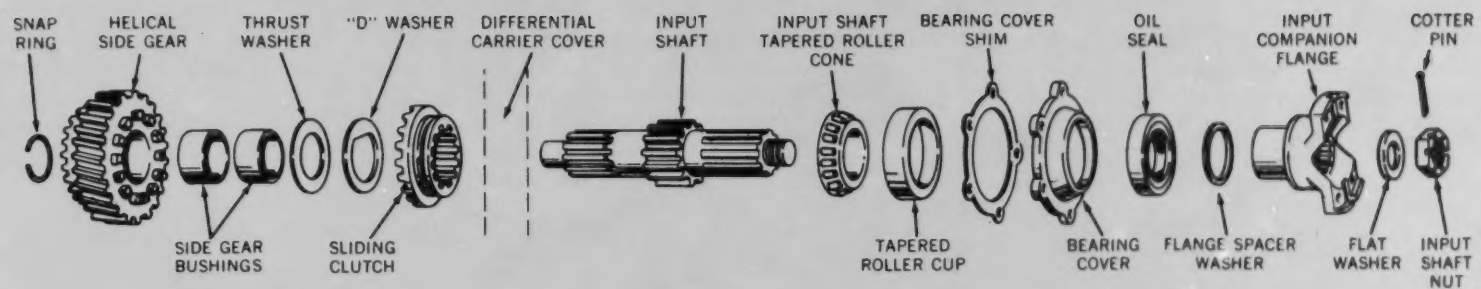
(NOTE: These power divider components should be assembled and reinstalled only after drive pinion and axle differential are assembled in the differential carrier and properly adjusted.)

2. Press front bearing cone on output shaft side gear

(NOTE: Refer to Figure 14 on the following page for parts references for this procedure.)

JOB SHEET #8

FIGURE 14



Exploded View of Input Shaft (with tapered roller bearing)

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JOB SHEET #8

3. Install rear snapring (adjacent to "O" rings) on output shaft
4. Place side gear assembly on output shaft
5. Install front snapring
6. Install two "O" rings in grooves of output shaft
7. Lubricate output shaft "O" rings, front bearing, and bushing
8. Install output shaft assembly in differential carrier by placing front bearing cone on bearing cup in bore of carrier

JOB SHEET #8

- R. Stop at this point and have your instructor check and initial your procedure and safe practice

INSTRUCTOR CHECK: Procedure ☐ Safety ☐ Initials ☐

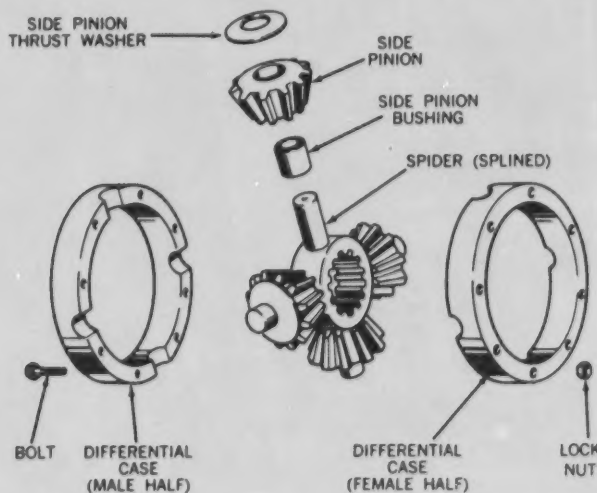
- S. Assemble and reinstall inter-axle differential with the following procedure (Figure 15):

1. Install bushings, side pinions, and thrust washers on journals of differential spider

(NOTE: Lubricate internal parts of inter-axle differential during re-assembly.)

2. Place spider assembly in male differential case
3. Install female differential case, aligning punch marks made during disassembly, and secure assembly with bolts and nuts
4. Tighten nuts to correct torque
5. Place inter-axle differential on the output shaft side gear which is mounted on output shaft
6. Position differential with nuts away from output shaft side gear

FIGURE 15



Exploded View of Inter-Axle Differential

JOB SHEET #8

- T. Stop at this point and have your instructor check and initial your procedure and safe practice

INSTRUCTOR CHECK: Procedure ☐ Safety ☐ Initials ☐

- U. Install lockout (air-operated type) with the following procedure (Figure 16):

1. Install push rod, seal retainer, and felt seal in carrier cover
2. Engage shift fork with groove in input shaft sliding clutch, then place this assembly in carrier cover

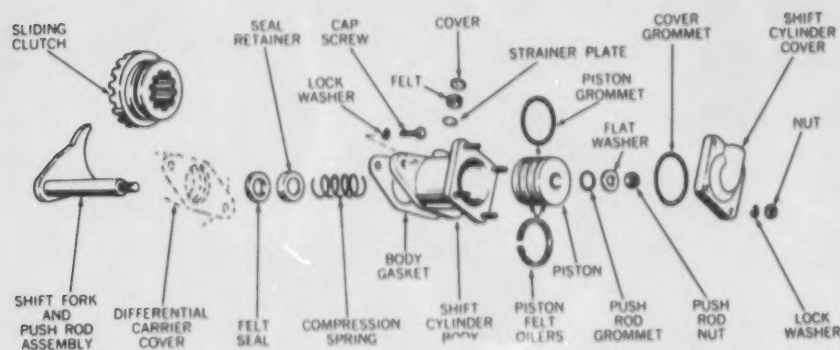
(NOTE: Before installing cylinder body, make certain strainer plate vent screens and felt are clean.)

3. Place compression spring gasket and shift cylinder body over gasket rod and on carrier cover, secure body with cap screws and lockwashers, and tighten screws to correct torque

(NOTE: Prior to assembly, the piston felt oilers should be soaked in SAE-30 oil for one hour.)

4. Install felt oilers and grommet on piston, then insert piston assembly in body and on push rod
5. Place grommet on push rod, then install flat washer and nut, and tighten push rod nut to 20-26 ft lb torque
6. Install grommet on cylinder body cover, then install cover, lockwashers, and nuts, and tighten cover nuts to 9-11 ft lb torque

FIGURE 16



Exploded View of Air-Operated Lockout Mechanism

JOB SHEET #8

- V. Stop at this point and have your instructor check and initial your procedure and safe practice

INSTRUCTOR CHECK: Procedure ☐ Safety ☐ Initials ☐

- W. Assemble and reinstall input shaft with the following procedure (Figure 17):

1. Press tapered roller bearing cone on threaded end of the input shaft, making certain the bearing cone is fully seated
2. Place input shaft and bearing assembly in differential cover engaging the sliding clutch
3. Place "D" washer on shaft so that it seats properly on the flatted surface
4. Lubricate and install thrust washer against "D" washer
5. Lubricate and install the helical side gear and bushings assembly on shaft
6. Install snapping in input shaft groove to secure the parts previously assembled

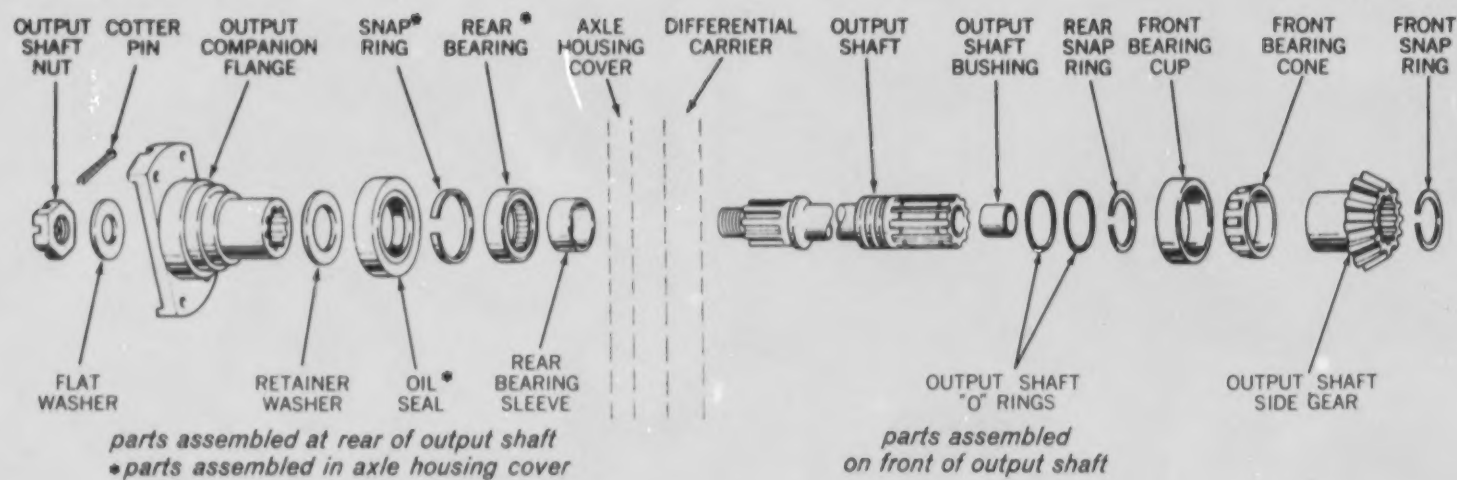
(NOTE: Figure 17 appears on the following page.)

- X. Stop at this point and have your instructor check and initial your procedure and safe practice

INSTRUCTOR CHECK: Procedure ☐ Safety ☐ Initials ☐

JOB SHEET #8

FIGURE 17



Exploded View of Output Shaft and Axle Housing Cover Parts

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JOB SHEET #8

Y. Reinstall differential carrier cover with the following procedure:

1. Clean gasket surface on differential carrier and install **new, dry** gasket
2. Place carrier cover assembly on differential carrier, aligning dowel pins with holes in cover
3. During assembly of cover to carrier, slowly rotate the input shaft to allow the shaft splines to align with and engage the splines in the bore of the inter-axle differential spider
4. Install two cover cap screws, one on each side of cover, and tighten evenly, watching for possible binding between cover and carrier
5. If the cover assembles to the carrier without binding, install the remaining cap screws and tighten to 115 to 124 lb ft torque

(NOTE: Make certain oil drain back holes are clean and aligned when assembling the following parts.)

6. Lubricate and install bearing cup and oil seal in the bearing cover
7. Clean and lubricate the tapped holes and cap screws to assure correct tightening torque values during the procedure that follows
8. Lubricate the bearing cone and install the bearing cup, seal, and cover assembly on the carrier cover
9. Install the bearing cover cap screw without lockwashers and torque evenly to 45 in lb torque
10. Using the companion flange, rotate the input shaft one quarter turn in each direction several times to seat the bearing cones into their cups, and recheck cap screw torques to 45 in lb torque

(NOTE: From this point on, until the completion of step 14, do not rotate the input shaft.)

11. Using a feeler gauge, measure the clearance between the bearing cover and the carrier cover; this clearance plus 0.015 inch should equal the thickness of shims for the correct bearing clearance
12. Remove the bearing cover and install the indicated shim pack as determined in step 11
13. Using a suitable sealer on the cap screw threads, install the cap screws and lock washers, and tighten cap screws to 75-85 ft lb torque

JOB SHEET #8

14. Check the end play of the input shaft by fastening a dial indicator to the carrier cover and mounted against the end of the input shaft so as to read the axial (in and out) movement of the input shaft

(NOTE: Do not attempt to measure end play by moving the input shaft up and down or side to side, as this will result in an incorrect reading.)

15. Using hand pressure, push in and pull on the input shaft, noting the total axial movement reading of the dial indicator; the indicated end play movement should be between .003" to .007"
16. If the reading is not within the above limits, adjust end play by either adding to or removing the required amount of shims from under the bearing cover assembly to obtain the specified clearance of .003" to .007"

17. After adding or removing shims, recheck end play with the procedure previously described

18. Install flange spacer washer (if used), companion flange, hardened flat washer, and nut on input shaft, and tighten nut to 500-700 ft lb torque and install cotter pin

(NOTE: The proper function of the power divider assembly can be checked by holding the output shaft stationary and making certain the input shaft can be rotated.)

19. Check to make certain a spacer washer is placed between the bearing cone and the companion flange, if required

(NOTE: All 50D, D340, D380, and D400 Series model axles utilize such a spacer washer; other models do not.)

- Z. Stop at this point and have your instructor check and initial your procedure and safe practice

INSTRUCTOR CHECK: Procedure ☐ Safety ☐ Initials ☐

- AA. Install differential carrier and power divider assembly into axle housing with the following procedure:

1. Place new carrier gasket on differential carrier
2. Install differential carrier and power divider assembly in axle housing
3. Install lock washers and tighten stud nuts to correct torque

JOB SHEET #8

BB. Assemble and install axle housing cover with the following procedure:

1. Before installing axle housing cover, assemble cover as follows (refer to Figure 14):
 - a) Press output shaft rear bearing in cover
 - b) Install snapping to secure bearing
 - c) Press oil seal in same opening in axle housing cover
2. Place **new** cover gasket on axle housing and install axle housing cover assembly, taking care not to damage oil seal
3. Install stud nuts and lockwashers, and tighten stud nuts to correct torque
4. Install rear bearing sleeve on output shaft
5. Install retainer washer, output companion flange, flat washer, and nut on output shaft
6. Tighten nut to correct torque and install cotter pin

CC. Install shafts and controls, and lubricate with the following procedure:

1. Install axle shafts and fill axle with correct lubricant
(NOTE: Check Maintenance Manual EA-20 for lubrication specifications.)
2. Connect propeller shafts to companion flanges
3. If axle is 2-Speed, install seal, spring, and shift unit on carrier
4. Make certain shift fork actuating lever engages slot in shift fork
5. Install stud nuts and flat washers, and tighten nuts to correct torque
6. Connect tubing or wiring to shift unit as necessary

DD. Stop at this point and have your instructor check and initial your procedure and safe practice

INSTRUCTOR CHECK: Procedure ☐ Safety ☐ Initials ☐

DIFFERENTIALS AND FINAL DRIVES
UNIT VII

JOB SHEET #9--DISASSEMBLE A PLANETARY GEAR ASSEMBLY OUTER ENDS

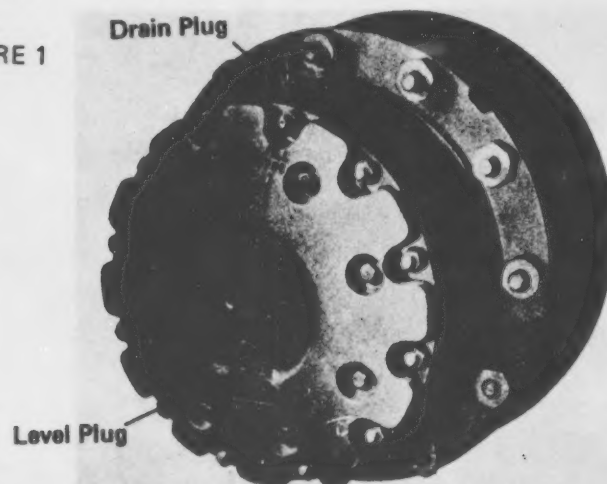
(NOTE: Procedure and illustrations courtesy Rockwell International.)

- I. Tools and equipment
 - A. Basic hand tools
 - B. Floor jack
 - C. Jack stands
 - D. Socket set, 3/4" drive
 - E. Socket set, 1/2" drive
 - F. Drain pan
 - G. Shop towels
 - H. Appropriate service manual
 - I. Safety glasses
- II. Procedure

(NOTE: Check service manual for the specific assembly your are working with; procedures vary from manufacturer to manufacturer.)

- A. Jack up both ends of axle so that tires clear the ground
- B. Put jack stands under axles
- C. Remove the wheel nuts or rim lug nuts where employed
- D. Remove the tire and wheel or tire or rim where employed
- E. Rotate hub assembly so that the drain plug is at the bottom (Figure 1)

FIGURE 1



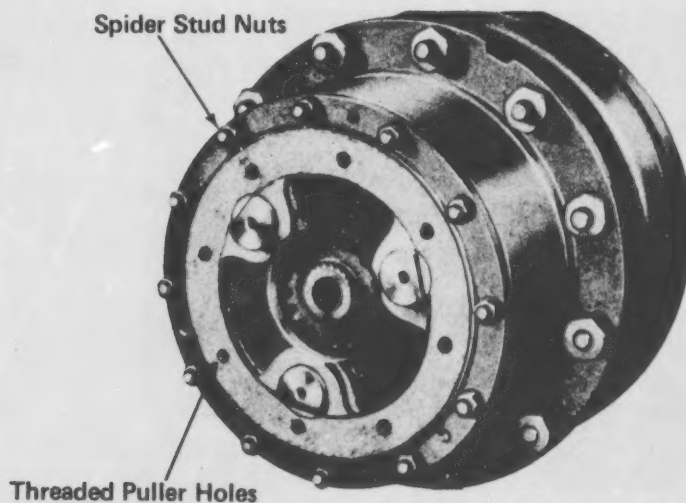
JOB SHEET #9

- F. Remove the drain plug and drain lubricant, removal of level plug will aid in draining
- G. Disassembly of planetary assembly
1. Remove the planetary wheel cover cap screws and wheel cover (Figure 2)



2. Remove the planetary spider stud nuts and lock washers (Figure 3)

FIGURE 3

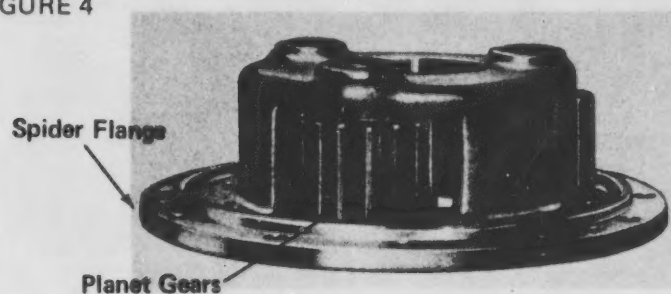


JOB SHEET #9

3. Separate and remove planetary spider assembly from wheel hub assembly (Figure 4)

(CAUTION: Assembly is very heavy; handle with care.)

FIGURE 4



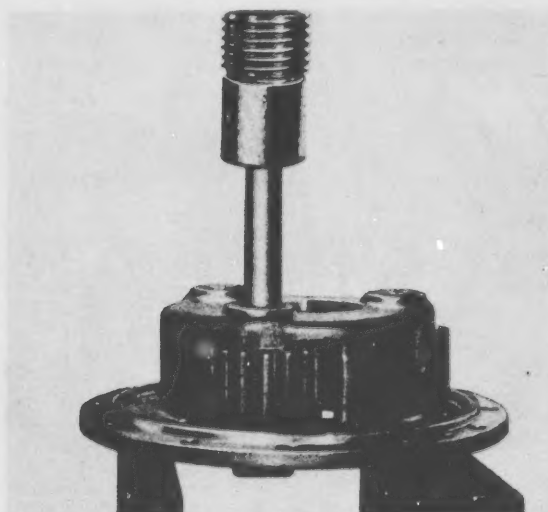
(NOTE: Use puller screws in threaded holes when provided in the spider flange [Figure 5].)

H. Disassemble planetary spider assembly

1. Press out the planet gear pins as shown (Figure 5)

(NOTE: Planetary spur gears rotate on planet pins. Each gear rotates between thrust washers.)

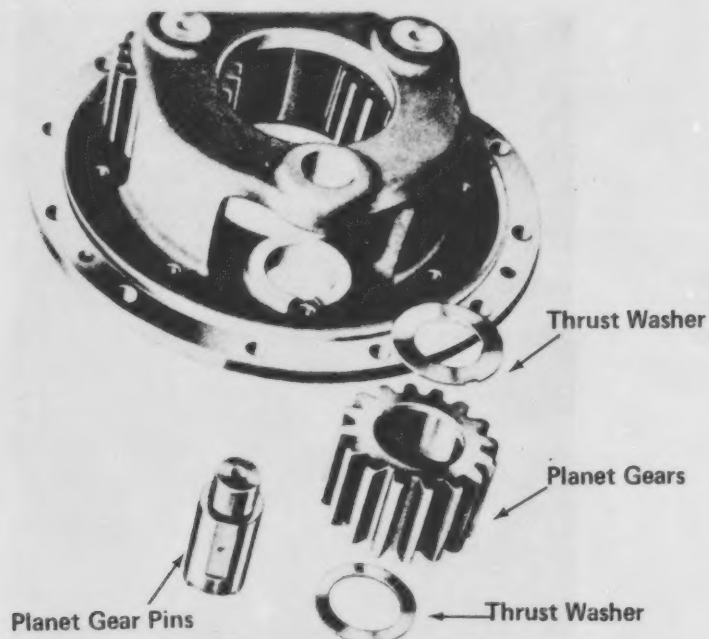
FIGURE 5



JOB SHEET #9

2. Remove the planet gears and their respective thrust washers (Figure 6)

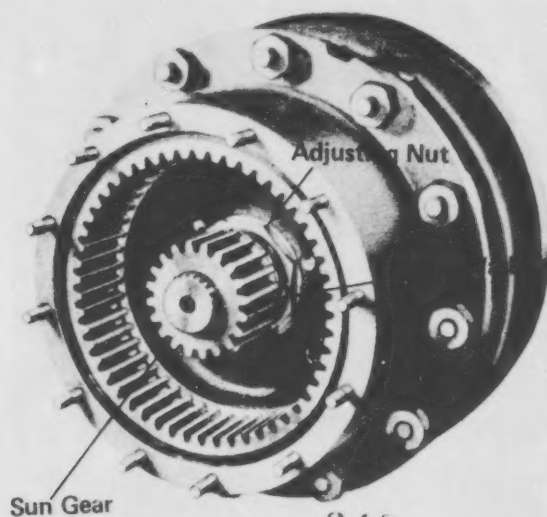
FIGURE 6



(NOTE: Thrust washers are designed for opposite sides of planet gears and can only be installed in their correct locations.)

- I. Remove the floating ring gear assembly
 1. Remove the lock ring or snap ring from end of axle shaft, and remove the axle shaft sun gear and thrust washer (Figure 7)

FIGURE 7



JOB SHEET #9

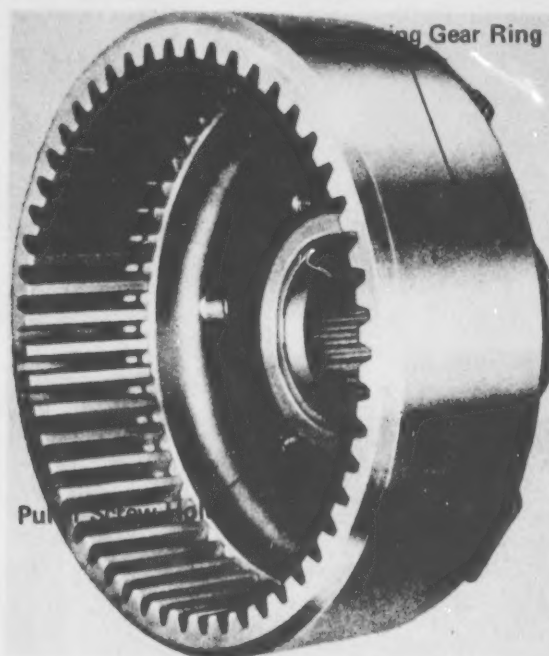
2. Remove the wheel bearing lock nut and wheel bearing adjusting nut (Figure 7)

(NOTE: Wheel bearing adjusting nuts are all of the single nut construction and may be locked to the hub spindle in different methods depending on model.)

3. Remove the floating ring gear assembly (Figure 8)

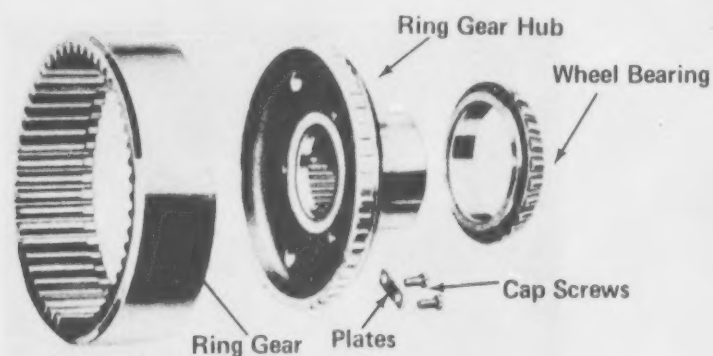
(NOTE: Use the puller screw holes provided in the ring gear hub.)

FIGURE 8



4. Separate the ring gear and ring gear hub by removing lock wire, cap-screws, and plates (Figure 9)

FIGURE 9



JOB SHEET #9

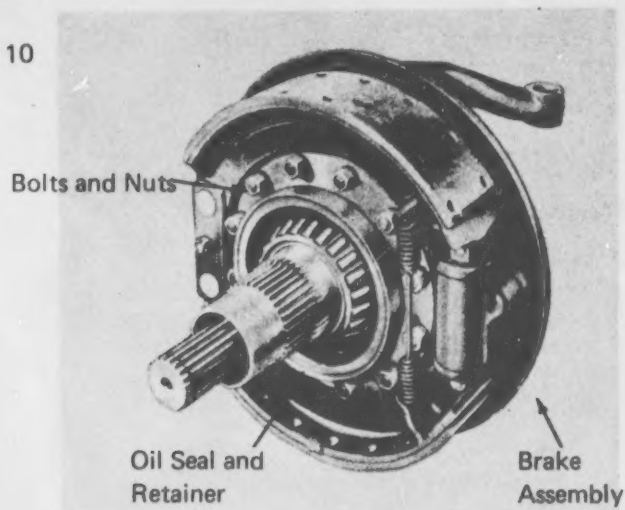
5. Remove outer wheel bearing from ring gear hub (Figure 9)

J. Remove planetary hub spindle

(NOTE: It is not necessary to disassemble the brake assembly to remove hub spindle on some models.)

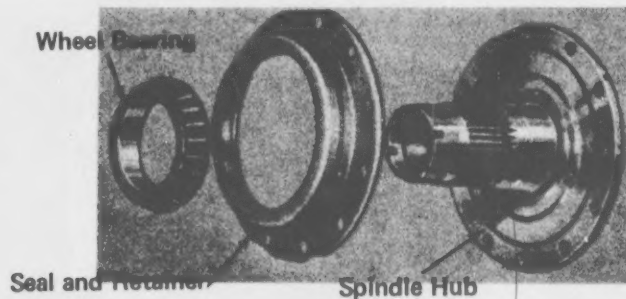
1. Remove bolts, nuts and lock washers from hub spline and brake assembly (Figure 10)

FIGURE 10



2. Remove hub spindle retainer and oil seal (Figure 11)

FIGURE 11



DIFFERENTIALS AND FINAL DRIVES
UNIT VII

JOB SHEET #10-CLEAN AND INSPECT PARTS OF A PLANETARY AXLE

- I. Tools and equipment
 - A. Solvent
 - B. Solvent wash container
 - C. Drop light
 - D. Clean shop towels
 - E. Safety glasses
- II. Procedure
 - A. Inspect planetary axles
 - B. Inspect all bearing cups and cones
 - C. Inspect the planetary reduction, planet gears, sun gear, and ring gear assembly for wear or damage
 - D. Inspect planetary reduction for:
 - 1. Pitted, scored, or worn thrust washers
 - 2. Worn or ridged planet pinion pins
 - 3. Torsional fractures or other signs of failure in axle shafts

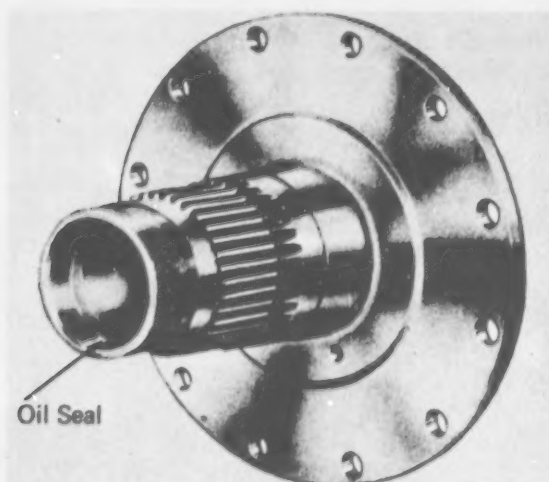
DIFFERENTIALS AND FINAL DRIVES UNIT VII

JOB SHEET #11--REASSEMBLE A PLANETARY GEAR ASSEMBLY

(NOTE: Procedure and illustrations courtesy Rockwell International.)

- I. Tools and equipment
 - A. Basic hand tools
 - B. Socket set, 1/2" drive
 - C. Torque wrench
 - D. Shop towels
 - E. Safety glasses
- II. Procedure
 - A. Install new seal from outer end with suitable driver if replacement of the spindle inner oil seal is necessary (Figure 1)

FIGURE 1



- B. Install the inner wheel bearing or cone on the hub spline
- C. Position the hub spindle and wheel bearing assembly on the brake assembly (knuckle flange studs)
- D. Place the oil seal and retainer assembly over the studs and install the flat washers and stud nuts, and tighten nuts to correct torque

JOB SHEET #11

E. Assemble floating ring gear assembly

1. Install splined ring gear hub into the ring gear splines
2. Install the hub to gear connecting plates and capscrews and tighten to correct torque
3. Install outer wheel bearing on ring gear hub

F. Assemble hub and drum assembly and install to procedure as outlined in previous job sheet

G. Assemble planetary spider (Figure 2)

1. Place the planetary spider cage on a bench
2. Align inner thrust washer hole with planet pin hole so that locating tab of washer lies in spider indent
3. Slide in planet gear and outer thrust washer and align bores
4. Press in the planet pin, small diameter end first
5. Outer end of pins must be turned so that the machined flat is to the outside of hub circle
6. Planet pins should be pressed through until the shoulder of pin butts thrust washer

FIGURE 2



JOB SHEET #11

- H. Install spider and pinion assembly
 - 1. Install spider to hub gasket
 - 2. Start the spider and pinion assembly, aligning teeth of planet pinions with sun gear and ring gear teeth
 - 3. Align hub onto studs and push spider assembly onto studs
 - 4. Install lock washers and nuts and tighten to correct torque
- I. Install new cover gasket, and install hub cover, and tighten to correct torque
- J. Check lubrication and refill to manufacturer's specification

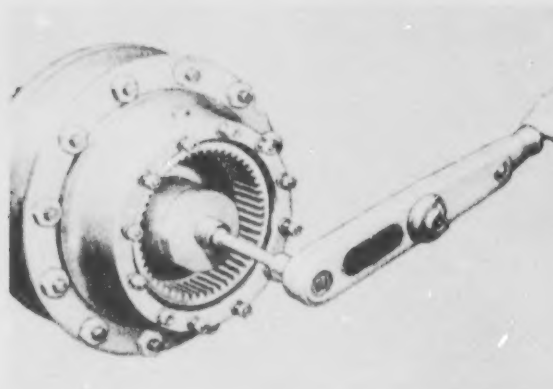
DIFFERENTIALS AND FINAL DRIVES
UNIT VII

JOB SHEET #12--ADJUST A PLANETARY GEAR BEARING PRELOAD

(NOTE: Procedure and illustrations courtesy Rockwell International.)

- I. Tools and equipment
 - A. Torque wrench
 - B. Roll of soft wire
 - C. Basic hand tools
 - D. Socket set, 3/4" set
 - E. Safety glasses
 - F. Pull scale
- II. Procedure
 - A. Tighten the adjusting nut against the ring gear to manufacturer's specification while the wheel is being rotated (Figure 1)

FIGURE 1

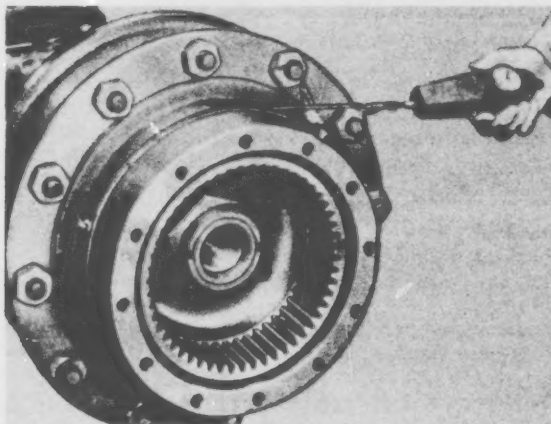


- B. Back off adjusting nut 1/4 turn to relieve preload on bearing

JOB SHEET #12

- C. Check the rotating torque by means of a pull scale and cord and advance the adjusting nut in small increments until the proper preload for the particular axle model (Figure 2)

FIGURE 2



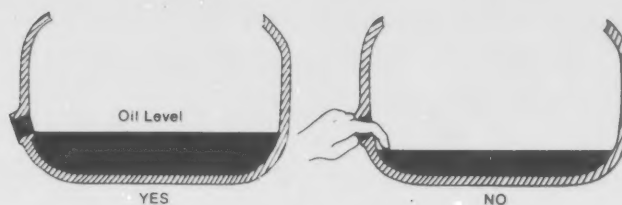
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DIFFERENTIALS AND FINAL DRIVES UNIT VII

JOB SHEET #13--PERFORM PREVENTIVE MAINTENANCE ON DIFFERENTIAL AND FINAL DRIVES

- I. Tools and equipment
 - A. Basic hand tools
 - B. Drop light
 - C. Creeper
 - D. Shop towels
 - E. Drain pan
 - F. Safety glasses
- II. Procedure
 - A. Check for proper oil level (Figure 1)

FIGURE 1



Courtesy Transmission Division, Eaton Corporation

JOB SHEET #13

- B. Drain oil if required
 - 1. Drain while warm
 - 2. Remove drain plug at bottom of case
 - 3. Clean drain plug before re-installing
 - 4. Install drain plug
- C. Refill oil if required
 - 1. Clean area around filler plug and remove plug from side to side
 - 2. Fill case to the level of the filler opening
- D. Add only recommended oil; do not mix brands or different grades
- E. Check with manufacturer's specification on what types of lubricant to use at different temperatures and load ranges
- F. Check to make sure axle vent is not clogged when checking oil level

DIFFERENTIALS AND FINAL DRIVES UNIT VII

JOB SHEET #14-ASSEMBLE AIR LINE WITH REUSABLE FITTING (FLARED)

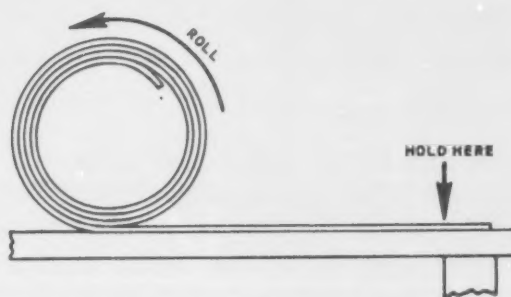
I. Tools and equipment

- A. Basic hand tools
- B. Roll of copper tubing
- C. Tubing cutter
- D. Flaring tool
- E. Shop towels
- F. Nylon fittings as provided by instructor
- G. Safety glasses

II. Procedure

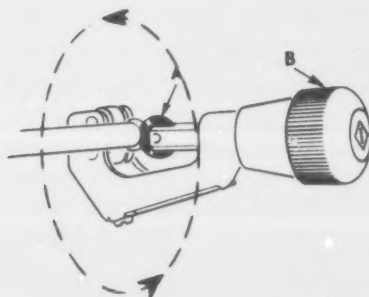
- A. Place roll of tubing on a clean bench in an upright position, hold the free end with one hand and unroll the tubing with other hand (Figure 1)

FIGURE 1



- B. Select the length of tubing needed for job and cut with tubing cutter (Figure 2)

FIGURE 2

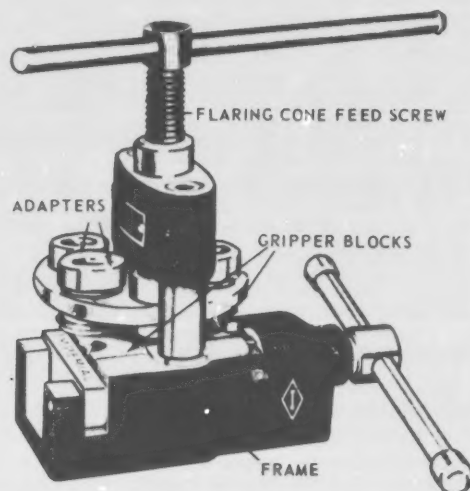


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JOB SHEET #14

- C. After cutting the correct length of tubing the ends will have to be flared (Figure 3)

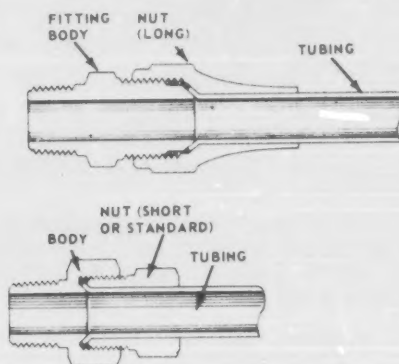
FIGURE 3



(CAUTION: Before flaring tubing select the size and type of connector nut and slide them on tubing **before** flaring.)

- D. Align the tubing with the fitting, and shove the flare against the fitting seat and run the nut up finger tight (Figure 4)

FIGURE 4



- E. Use a flare nut wrench and tighten nut up solidly until you feel a metal-to-metal contact, at this point give the nut an additional 60° turn

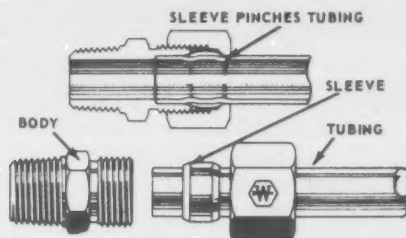
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DIFFERENTIALS AND FINAL DRIVES
UNIT VII

JOB SHEET #15--ASSEMBLE AIR LINE WITH COMPRESSION FITTINGS

- I. Tools and equipment
 - A. Basic hand tools
 - B. Roll of tubing (copper, rigid plastic)
 - C. Tubing cutter
 - D. Shop towels
 - E. Safety glasses
- II. Procedure
 - A. Cut tubing length that is needed to do job
 - B. Slide the nut, followed by the sleeve, on the tubing (Figure 1)

FIGURE 1



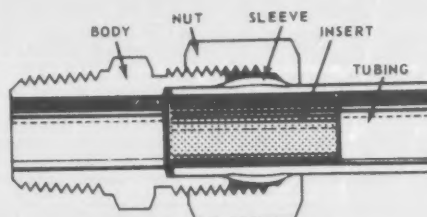
- C. Align the tubing with the fitting, and insert the tubing as far as it will go into the fitting
- D. While holding the tubing in, run up the nut finger tight

JOB SHEET #15

- E. Use a flare nut wrench, bring up nut until the sleeve just grasps the tubing, then turn nut additional one and one-quarter turn

(NOTE: On soft plastic tubing a special insert is placed in the end so as not to crush the tube [Figure 2].)

FIGURE 2



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DIFFERENTIALS AND FINAL DRIVES UNIT VII

NAME _____

TEST

1. Match terms on right with the correct definitions.

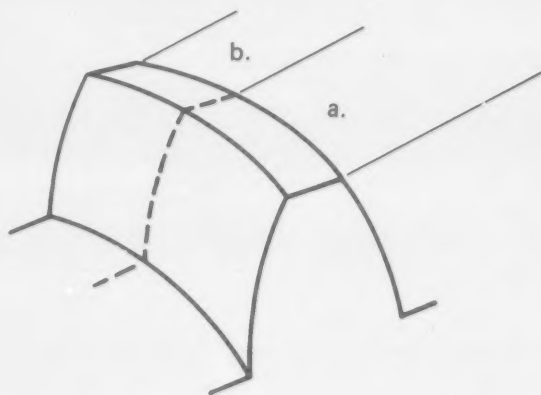
- | | |
|---|--------------------------------|
| _____ a. Arrangement of gears connecting two shafts or axles in the same line, dividing the driving force equally between them, and permitting one shaft to revolve faster than the other | 1. Hypoid gear |
| _____ b. The last phase of the power train; it gives the final reduction in speed and increase in torque to the drive wheels | 2. Gear tooth clearance |
| _____ c. Distance that one gear can be moved back and forth without moving the gear into which it is meshed | 3. Ring gear |
| _____ d. Name given to the bevel gear in a differential, and the gear which surrounds or rings the sun and planet gears in a planetary system | 4. Preload |
| _____ e. A gear that is similar in appearance to spiral bevel gear, but the driving gear is located below the center of the driven gear | 5. Planetary gearset |
| _____ f. A small gear having the teeth formed in the hub; it drives a larger gear | 6. Differential pinion |
| _____ g. Adjusting antifriction bearing so that it is under mild pressure; this prevents bearing looseness under a driving stress | 7. Backlash |
| _____ h. Distance separating two gear teeth that are meshed together | 8. Differential |
| _____ i. A method of testing the wiping action between ring gear and pinion gear to determine if they are properly adjusted | 9. Pinion |
| _____ j. A gearing unit consisting of a ring gear with internal teeth, a sun or central pinion gear with external teeth, and a series of planet gears that are meshed with both the ring and the sun gear | 10. Tooth contact pattern test |
| _____ k. Small gears mounted on a shaft pinned to the differential case; they mesh with, and drive, the axle end gears | 11. Final drive |

2. Match types of differentials and final drives with their definitions.

- | | |
|--|------------------------------------|
| _____ a. Rear axle assembly with single reduction through ring gear and drive pinion | 1. Tandem drive axle |
| _____ b. Rear axle assembly with two reductions; one through ring and drive pinion, one through a set of helical gears | 2. Planetary double reduction axle |
| _____ c. Rear axle assembly with two gear ratios for various road and load conditions | 3. Double reduction axle |
| _____ d. Rear axle assembly incorporating two single axle units and power divider interconnected by a propeller shaft | 4. Planetary drive axle |
| _____ e. Rear axle assembly with two reductions; one through ring gear and drive pinion, one through planetary gearing | 5. Single reduction axle |
| _____ f. Rear axle assemblies which are more durable since torque loads are spread more evenly over several gears | 6. 2-speed axle |

3. Identify the parts of a gear tooth in the following drawing.

- a. _____
- b. _____
- c. _____
- d. _____
- e. _____



4. Match the methods used to evaluate gear tooth contact patterns with the correct diagrams.

_____ a.



_____ b.



_____ c.



_____ d.

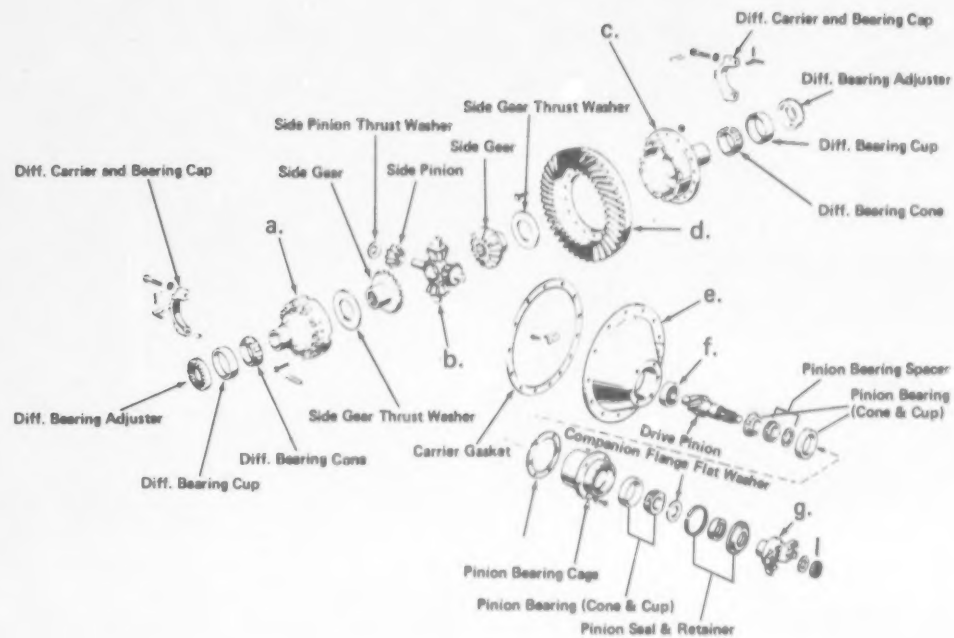


_____ e.



1. Toe contact--To correct move gear away from pinion
2. High tooth contact--To correct move pinion toward gear
3. Heel contact--To correct move gear toward pinion
4. Ideal contact
5. Low tooth contact--To correct move pinion away from gear

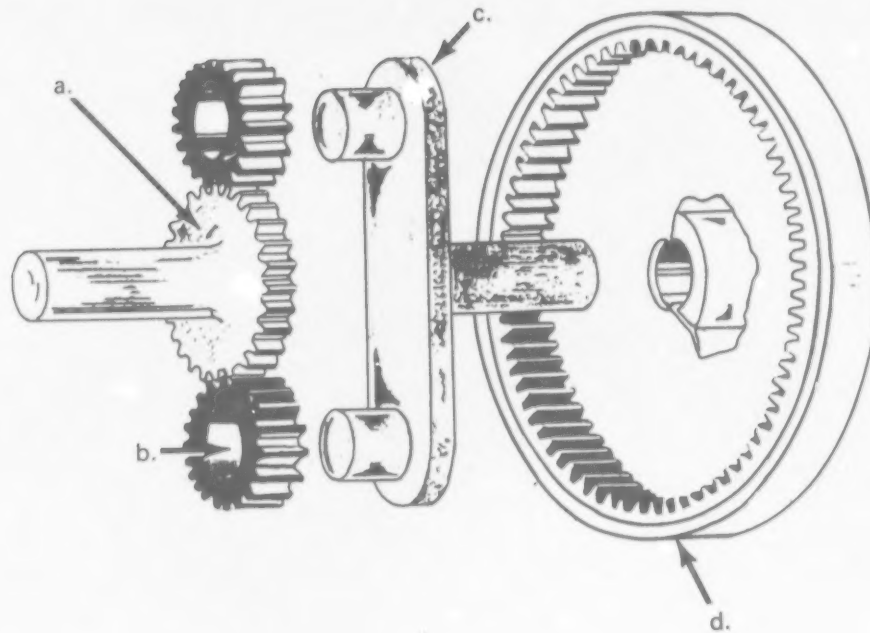
5. Identify parts of a differential by correctly labeling the unnamed parts in the following illustration.



a. _____
 b. _____
 c. _____
 d. _____

e. _____
 f. _____
 g. _____

6. Identify parts of a planetary gearset and write correct answers in blanks provided.



- a. _____
- b. _____
- c. _____
- d. _____

7. Match planetary gearset components with their characteristics.

- | | |
|---|-------------------|
| _____ a. The center gear in mesh with the planet gears | 1. Ring gear |
| _____ b. Those gears in a planetary gearset that are in mesh with both the ring and the sun gear | 2. Planet gear |
| _____ c. That part of a planetary gearset upon which the planet gears are affixed | 3. Sun gear |
| _____ d. The large gear with internal teeth in mesh with the teeth of the planet pinions at all times | 4. Planet carrier |

8. Name three types of differential locks.

a. _____

b. _____

c. _____

9. Select from the following list the purposes of a power divider by placing an "X" in the appropriate blanks.

_____ a. Equally distributes power from the vehicle transmission to both the forward and rear rear axles

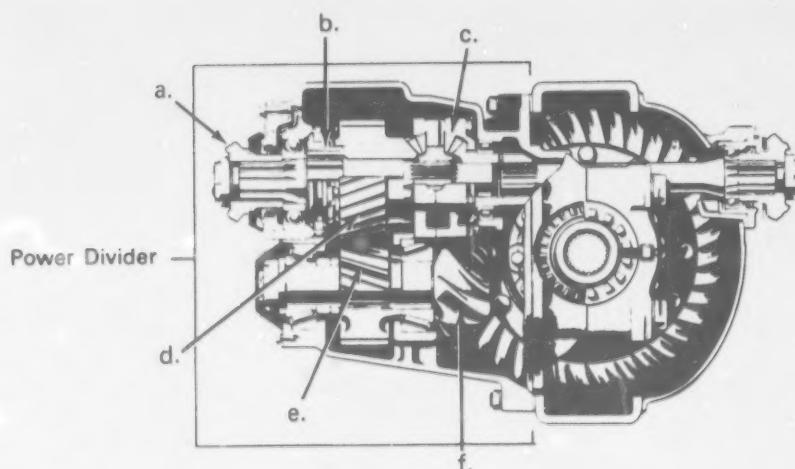
_____ b. On a tandem drive axle, when power divider is disengaged, the two axles act as one axle

_____ c. When power divider is disengaged, it prevents axle fight and permits freer rolling

_____ d. Provides maximum traction when road conditions are unfavorable

_____ e. Allows for easier steering and better roadability

10. Identify the basic parts of a power divider by matching names to parts and writing correct answers in blanks provided.

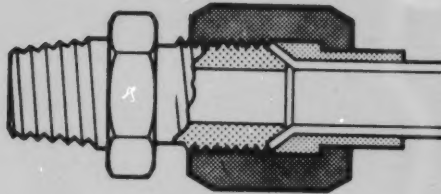


- | | |
|----------------------------------|---|
| _____ 1) Helical side gear | _____ 4) Input shaft |
| _____ 2) Drive pinion | _____ 5) Inter-axle differential lock-out |
| _____ 3) Inter-axle differential | _____ 6) Pinion helical gear |

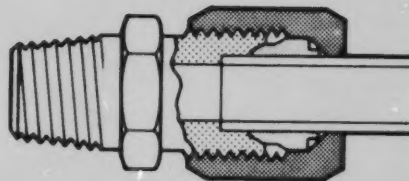
11. Match types of shifting mechanisms with their descriptions.

- | | |
|--|--------------------------|
| _____ a. Consists of a manually-operated control switch and an electric shift unit; connected by electrical cables and normally protected by a circuit breaker; the shift unit includes a reversible electric motor, automatic switch, drive screw, and torsion spring drive | 1. Air-operated shift |
| _____ b. Consists of manually operated air shifter valve, a quick release valve, and an axle shift unit; air shifter supplies air through the quick release valve to the axle shift unit; air pressure in the shift unit shifts axle to high range; to shift axle to low range, air pressure is exhausted at shifter valve, which exhausts air pressure at quick release valve | 2. Vacuum-operated shift |
| _____ c. Consists of a manually operated control lever, vacuum valve controlled by linkages, and an axle shift unit; vacuum can be used to shift the unit to low range; spring tension shifts the unit back to high range | 3. Electric shift |

12. Distinguish between flared and compression fittings in the illustrations below by placing an "X" beside the flared fitting.



_____ a.



_____ b.

13. Demonstrate the ability to:

- a. Remove a differential assembly.
- b. Disassemble a differential case and gear assembly.
- c. Clean and inspect a differential case and gear assembly.
- d. Adjust drive pinion bearing preload.
- e. Reassemble a differential case and gear assembly.
- f. Adjust differential bearing preload; check gear backlash and tooth contact pattern.
- g. Install differential assembly in differential housing.
- h. Remove, repair, and reassemble a differential carrier and power divider assembly.
- i. Disassemble a planetary gear assembly outer ends.
- j. Clean and inspect parts of a planetary axle.
- k. Reassemble a planetary gear bearing preload.

- l. Adjust a planetary gear assembly.
- m. Perform preventive maintenance on differential and final drives.
- n. Assemble air line with reusable fitting (flared).
- o. Assemble air line with compression fittings.

(NOTE: If these activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

DIFFERENTIALS AND FINAL DRIVES
UNIT VII

ANSWERS TO TEST

1. a. 8 g. 4
 b. 11 h. 2
 c. 7 i. 10
 d. 3 j. 5
 e. 1 k. 6
 f. 9
2. a. 5 d. 1
 b. 3 e. 2
 c. 6 f. 4
3. a. Heel
 b. Toe
 c. Face
 d. Pitch line
 e. Flank
4. a. 4 d. 2
 b. 1 e. 5
 c. 3
5. a. Differential case, plain half
 b. Spider
 c. Differential case, flanged half
 d. Ring gear
 e. Differential carrier
 f. Pinion pilot bearing
 g. Companion flange, pinion yoke
6. a. Sun gear
 b. Planet gear
 c. Planet carrier
 d. Ring gear
7. a. 3
 b. 2
 c. 4
 d. 1
8. a. Hydraulic lock
 b. Automatic lock
 c. Mechanical lock
9. a, c, d, e

10. 1) d 4) a
 2) f 5) b
 3) c 6) e

11. a. 3
 b. 1
 c. 2

12. a

13. Performance skills evaluated to the satisfaction of the instructor

POWER TAKE-OFFS UNIT VIII

UNIT OBJECTIVE

After completion of this unit, the student should be able discuss safe operation of power take-offs, list technical standards for power take-off drives, and trouble-shoot power take-offs for problems related to noise, heat, vibration, and other malfunctions. The student should also be able to install a transmission-mounted power take-off. This knowledge will be evidenced by correctly performing the procedures outlined in the job sheet and by scoring 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms related to power take-offs with their correct definitions.
2. Select true statements concerning safe operation of PTOs.
3. Identify three types of PTO guards and shields.
4. List three types of PTO systems.
5. List ASAE-SAE standards for tractor PTO drives.
6. Match complaints with causes for noise, heat, and vibration in transmission-mounted PTOs.
7. Select true statements concerning troubleshooting PTOs for poor work rate.
8. Match complaints with causes for external oil leaks in PTOs.
9. Select true statements concerning troubleshooting PTOs for hard shifting.
10. Complete a list of statements concerning troubleshooting PTOs for jumping out of gear.
11. Select true statements concerning troubleshooting power shift PTOs.
12. List subassembly parts of a two-gear, one-speed PTO.
13. Identify components of hydraulic and electric circuits in a power shift PTO.
14. List parts of a PTO air shift system.

15. Identify shifter covers for transmission-mounted PTOs.
16. Complete a list of procedures for lubricating PTO systems.
17. Complete a list of questions that are relevant when selecting the proper PTO.
18. Demonstrate the ability to install a transmission-mounted power take-off.

POWER TAKE-OFFS
UNIT VIII

SUGGESTED ACTIVITIES

- I. Provide student with objective sheet.
- II. Provide student with information and job sheets.
- III. Make transparencies.
- IV. Discuss unit and specific objectives.
- V. Discuss information sheet.
- VI. Demonstrate and discuss the procedures outlined in the job sheet.
- VII. Show films on operation, inspection, and repair of power take-offs.
- VIII. Demonstrate the operation of power take-offs on live equipment.
- IX. Demonstrate safety precautions on live equipment.
- X. Take field trip to a shop that installs power take-offs and power take-off operated equipment.
- XI. Give test.

INSTRUCTIONAL MATERIALS

- I. Included in this unit:
 - A. Objective sheet
 - B. Information sheet
 - C. Transparency masters
 1. TM 1--Types of PTO Guards and Shields
 2. TM 2--Types of PTO Systems
 3. TM 3--Transmission-Mounted PTO
 4. TM 4--Electric and Hydraulic Circuits for Power Shift PTO
 5. TM 5--Parts for a PTO Air Shift System
 6. TM 6--Shift Covers for Transmission-Mounted PTOs

- D. Job Sheet #1-Install a Transmission Mounted Power Take-Off
- E. Test
- F. Answers to test

II. References:

- A. *Chelsea Power Take-Off Troubleshooting Guide*. Toledo, OH 43691: Dana Corporation, 1979.
- B. *Chelsea Side Mounted Power Take-Off/6 & 8 Bolt Owner's Manual*. Toledo, OH 43691: Dana Corporation, 1979.
- C. *Fundamentals of Service: Power Trains*. Moline, IL 61265: John Deere Service Publications, Dept. F, 1972.

POWER TAKE-OFFS
UNIT VIII

INFORMATION SHEET

I. Terms and definitions

A. PTO--Power take-off

- B. Truck application PTO--A mechanical device attached to the side of the main transmission or the side or top of the auxiliary transmission; it transmits engine power to auxiliary equipment

(NOTE: In some cases, the PTO is attached to the front of the engine crankshaft.)

- C. Tractor PTO--An attachment in the power train of a machine to drive auxiliary equipment

(NOTE: On tractors, most PTOs are gear driven from the transmission and send power through a built-in shaft to the PTO outlet.)

- D. Independent PTO--A PTO system having its own clutch control completely separate from the engine clutch and transmission

- E. Transmission-driven PTO--Operates only when the engine clutch is engaged

(NOTE: This PTO has no separate clutch.)

- F. Continuous-running PTO--A PTO system that has two clutches, one for the transmission and one for the PTO; both are operated by one control

- G. Solid PTO shaft--Solid shaft with a fixed length and a U-joint at each end

(NOTE: This type of drive is used when power is to be transmitted from one fixed plane to another fixed plane.)

- H. Telescoping shaft--A shaft with a sliding or telescoping element; can have either two or three U-joints

- I. Tunnel shield--An inverted U-shaped piece of steel which covers the moving parts of a PTO shaft

- J. Spinner shield--A cylinder-shaped piece which surrounds the shaft and has a bell housing on each end to cover the U-joints

II. Safe operation of PTOs

- A. *Keep PTO guards and shields in place*

- B. *Never engage the PTO while the machine engine is shut off*

- C. *Keep hands, feet, and clothing away from PTO moving parts*

INFORMATION SHEET

- D. *Always disconnect the PTO when not in use*
- E. *Never wear loose clothing around PTO in operation*
- F. *Be sure spinner shields rotate freely*
- G. *Always be sure PTO drive shaft is properly secured to the machine PTO shaft*
- H. *Always disengage the machine PTO and shut off engine before servicing, lubricating, or performing repairs*
- I. *Always keep nuts and bolts tight on PTO shaft and PTO driven machine*
- J. *NEVER HOOK 540 PTO EQUIPMENT TO 1000 RPM PTO*
- K. *Always block dump beds when working on unit with bed raised*
- III. Types of PTO guards and shields (Transparency 1)
 - A. Spinner shield
 - B. PTO shaft guard
 - C. PTO master shield (tunnel shield)
- IV. Types of PTO systems (Transparency 2)
 - A. Transmission-driven
 - B. Continuous-running
 - C. Independent
- V. ASAE-SAE standards for tractor PTO drives
 - A. 540 rpm - 6 splines on PTO shaft
 - B. 1000 rpm - 21 splines on PTO shaft

(NOTE: ASAE, American Society of Agricultural Engineers, and SAE, Society of Automotive Engineers, set standards for tractor and equipment manufacturers.)
- VI. Complaints and causes for noise, heat, and vibration in transmission-mounted PTOs (Transparency 3)
 - A. Rattles or whines
 - 1. Backlash too tight (whine)
 - 2. Backlash too loose (rattle)

(NOTE: Backlash should be set at .006" to .012" between drive gear in transmission and driven gear in PTO.)

INFORMATION SHEET

- B. Clicking sound
 - 1. Worn, nicked, or burred gear
 - 2. Damaged bearing from improper installation
- C. Grinding noise
 - 1. Foreign material in bearing
 - 2. Transmission low on grease
- D. Vibration
 - 1. Drive line out of phase
 - 2. Excessive U-joint angle
 - 3. Drive line bent
 - 4. U-joints worn
 - 5. PTO loose on transmission
 - 6. Driven equipment loose
 - 7. High vibration equipment such as a piston type air compressor
 - 8. Worn splines on slip joint
- E. PTO running hot
 - 1. PTO installed too tight
 - 2. Low transmission oil level
 - 3. Prolonged stationary use
 - 4. PTO near exhaust or other heat source
 - 5. PTO overloaded

VII. Troubleshooting PTOs for poor work rate

- A. PTO torque rate too low for job being performed

(NOTE: Consult equipment manufacturer's specifications for proper speed, torque output, and rotation.)

- B. PTO output speed too high or too low for job being done

INFORMATION SHEET

VIII. Complaints and causes for external oil leaks in PTOs

A. Shaft seal leaking

1. Seal worn from age, heat, or drive line vibration

(NOTE: Dirt entering seal area can cause seal to fail, or operating at a temperature above 250°F can cause seal to fail.)

2. Seal retainer plate installed out of alignment

B. Leaking housing or mating surfaces

1. Porous or cracked housing
2. Broken or worn gasket
3. 6-bolt idler shaft poor fit
4. 8-bolt "O" ring not sealing on idler shaft
5. Copper washers needed under 6-bolt PTO mount bolts or nuts
6. Lock washer not under 8-bolt PTO mount bolts
7. "O" ring leaking on shifting post
8. Elongated mounting bolt holes

IX. Troubleshooting PTOs for hard shifting

- A. Backlash too tight
- B. Tight bend in shift cable
- C. Gear in backwards
- D. Loose fit on internal spline of sliding gear causing gear to bind
- E. Lever linkage needs redesign--not enough mechanical advantage
- F. Low air pressure for air shift

X. Troubleshooting PTOs for jumping out of gear

- A. Excessive load for PTO torque rating
- B. Gear teeth worn tapered
- C. Shifter poppet spring broken
- D. Shifter poppet spring hole elongated
- E. Shift rail poppet notch worn

INFORMATION SHEET

- F. Sprung or loose shift fork
- G. Air shift pressure low for complete shift
(NOTE: Air pressure should be from 60 to 70 PSI.)
- H. Cable or lever linkage not adjusted for full PTO engagement

XI. Troubleshooting power shift PTOs

(NOTE: Power shift PTOs are used on automatic transmissions.)

- A. Won't engage
 - 1. Transmission oil level low
 - 2. Clogged hose or screen
 - 3. Bad electrical connection
 - 4. Inoperative electrical switch
 - 5. Improper installation of electric or hydraulic shift circuit
 - 6. Inoperative solenoid valve
 - 7. Incorrect solenoid valve

(NOTE: Pressure is not sufficient to shift PTO due to wrong valve.)

- 8. Obstruction in hydraulic shift circuit
 - 9. Internal leakage in shifter
 - 10. Clutch plates worn in PTO
- B. Will engage but will not operate--system under load
 - 1. Low pressure supplied to PTO
 - 2. Clutch plates worn in PTO
- C. PTO will not disengage
 - 1. Improper installation of circuit
 - 2. Pressure too high
 - 3. Clutch plates in PTO welded together
- D. Noise, heat, vibration, improper work rate, and external oil leaks--
Troubleshooting procedures same as those used with transmission-mounted PTOs

INFORMATION SHEET

- XII. Subassembly parts of a two-gear, one-speed PTO (Transparency 3)
 - A. Shift cover assembly
 - B. PTO case
 - C. Output shaft and gear assembly
 - D. Drive gear and shaft assembly
- XIII. Components of hydraulic and electric circuits in a power shift PTO (Transparency 4)
 - A. Nine amp fuse
 - B. Indicator light
 - C. Switch
 - D. Hose from valve to PTO
 - E. Screen adapter
 - F. Solenoid valve
 - G. Dump line back to transmission through PTO
 - H. Screen adapter
 - I. Line from transmission to valve
- XIV. Parts of a PTO air shift system (Transparency 5)
 - A. Shift cover assembly
 - B. Indicator switch
 - C. Indicator light
 - D. Control valve
 - E. Pressure protection valve (pressure regulator)
- XV. Shifter covers for transmission-mounted PTOs (Transparency 6)
 - A. Cable control
 - B. Lever control
 - C. Air shift

INFORMATION SHEET

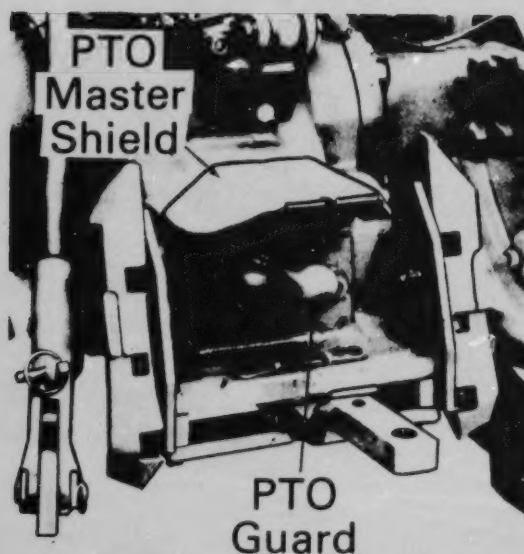
XVI. Procedures for lubricating PTO systems

- A. Check lubricant in transmission
- B. Lubricate U-joints
- C. Lubricate slip yoke
- D. Lubricate spinner shield
- E. Lubricate driven equipment according to manufacturer's recommendations

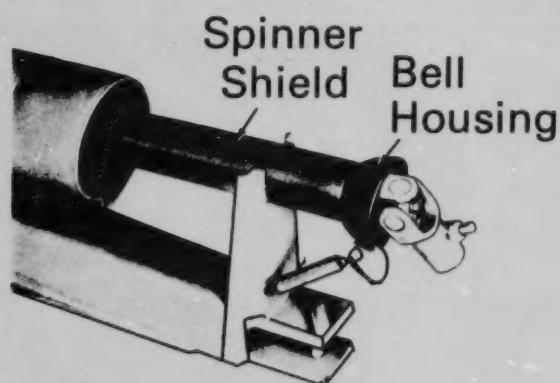
XVII. Questions that are relevant when selecting the proper PTO

- A. What is make and model of transmission?
- B. Which PTO opening will be used?
- C. What accessory will be driven?
- D. How much horsepower is required to drive accessory?
- E. What is the required rotation of PTO?
- F. What is required PTO output shift speed as a percent of engine speed?
- G. What is the required method of shifting PTO (cable, lever, or air)?

Types of PTO Guards and Shields



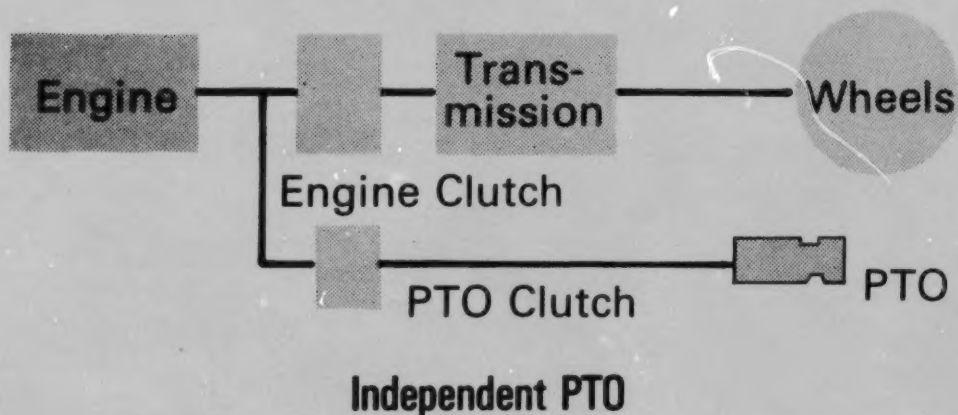
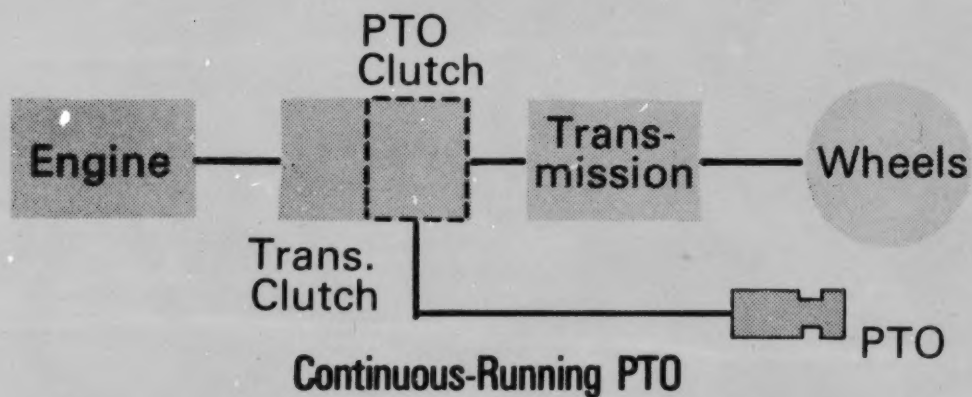
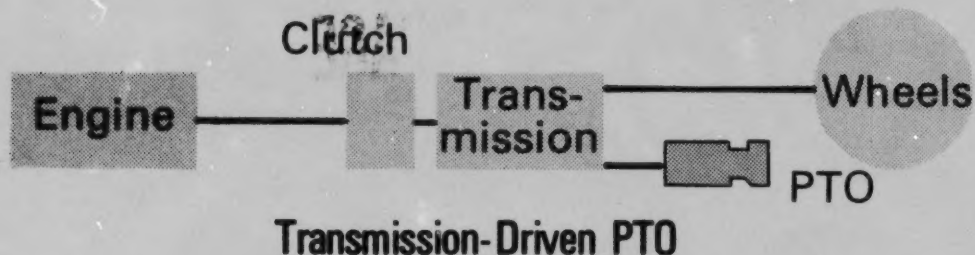
PTO Shaft Guard and Master Shield



Spinner Shield for PTO Drive Shaft

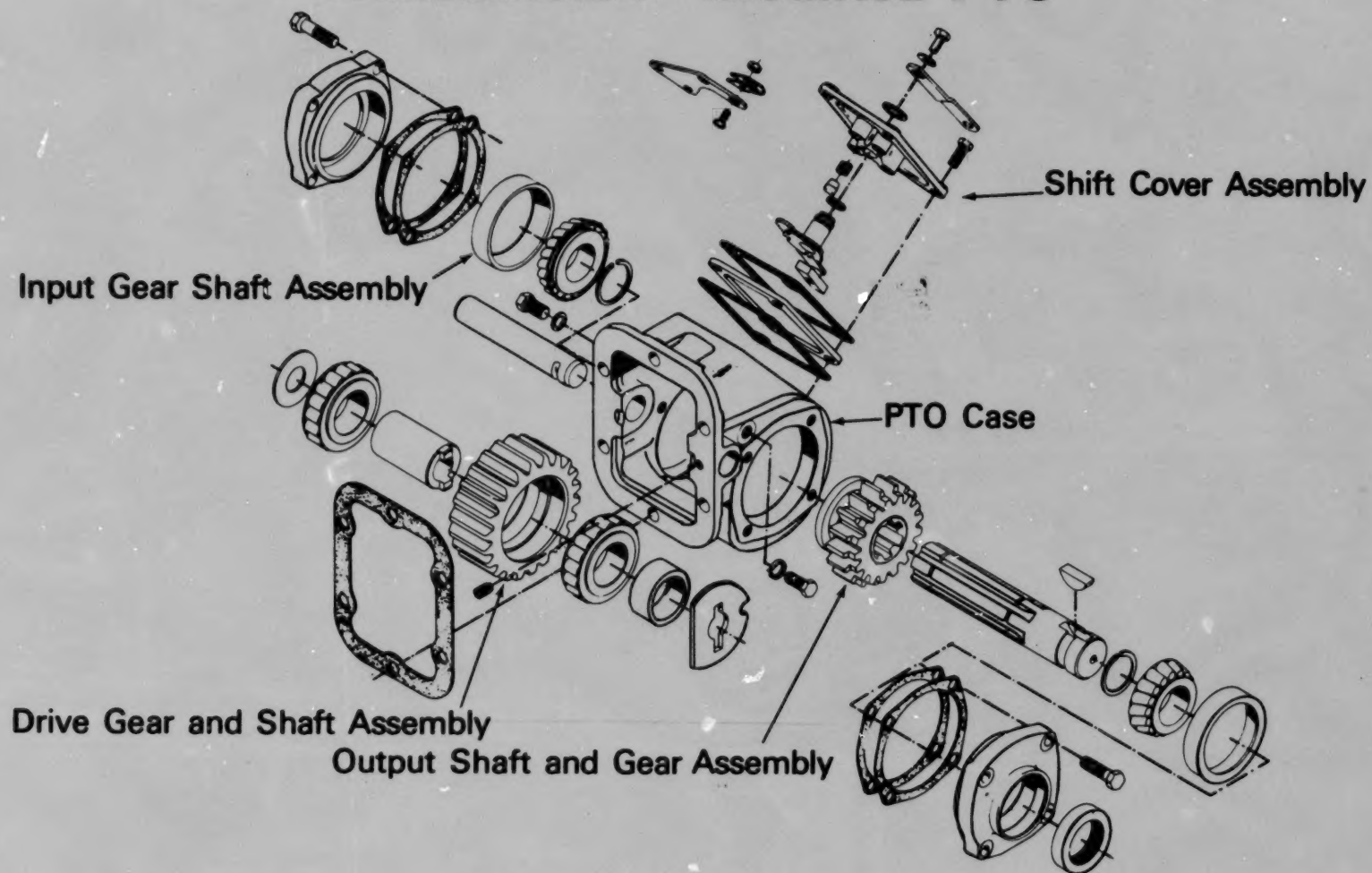
Courtesy DEERE & CO., MOLINE, IL

Types of PTO Systems

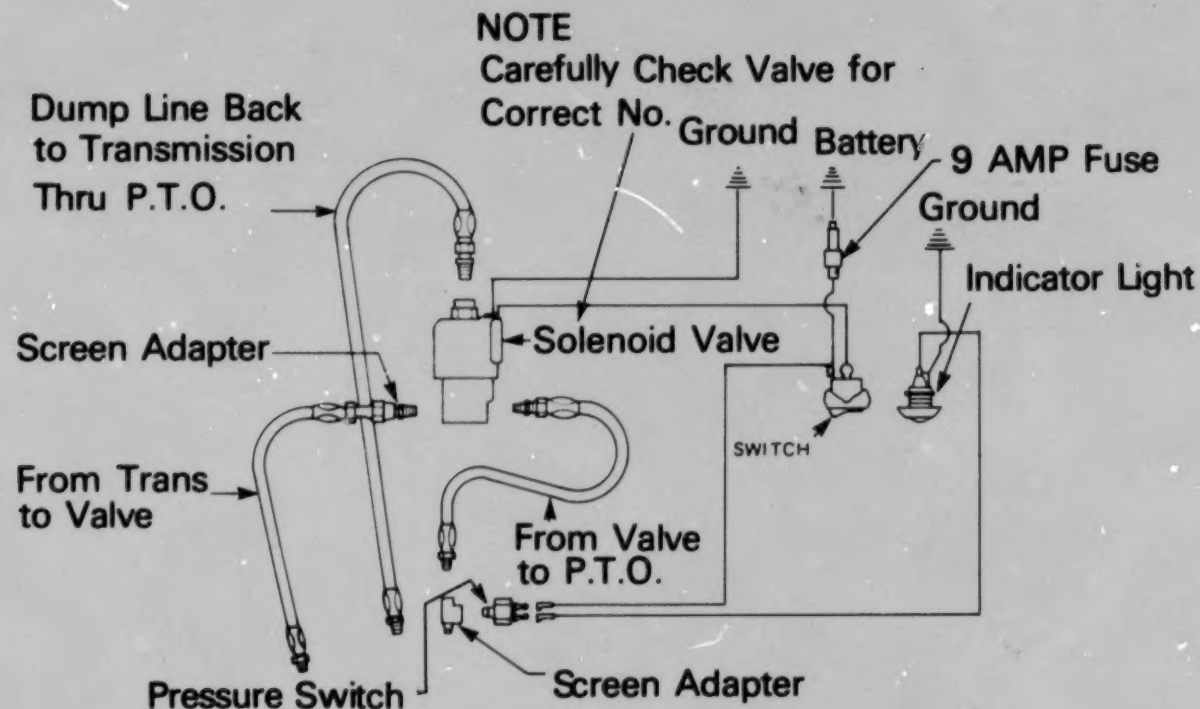


Courtesy DEERE & CO., MOLINE, IL

Transmission - Mounted PTO



Electric and Hydraulic Circuits for Power Shift PTO



Chelsea PTO component courtesy Drivetrain Service Division, Dana Corporation

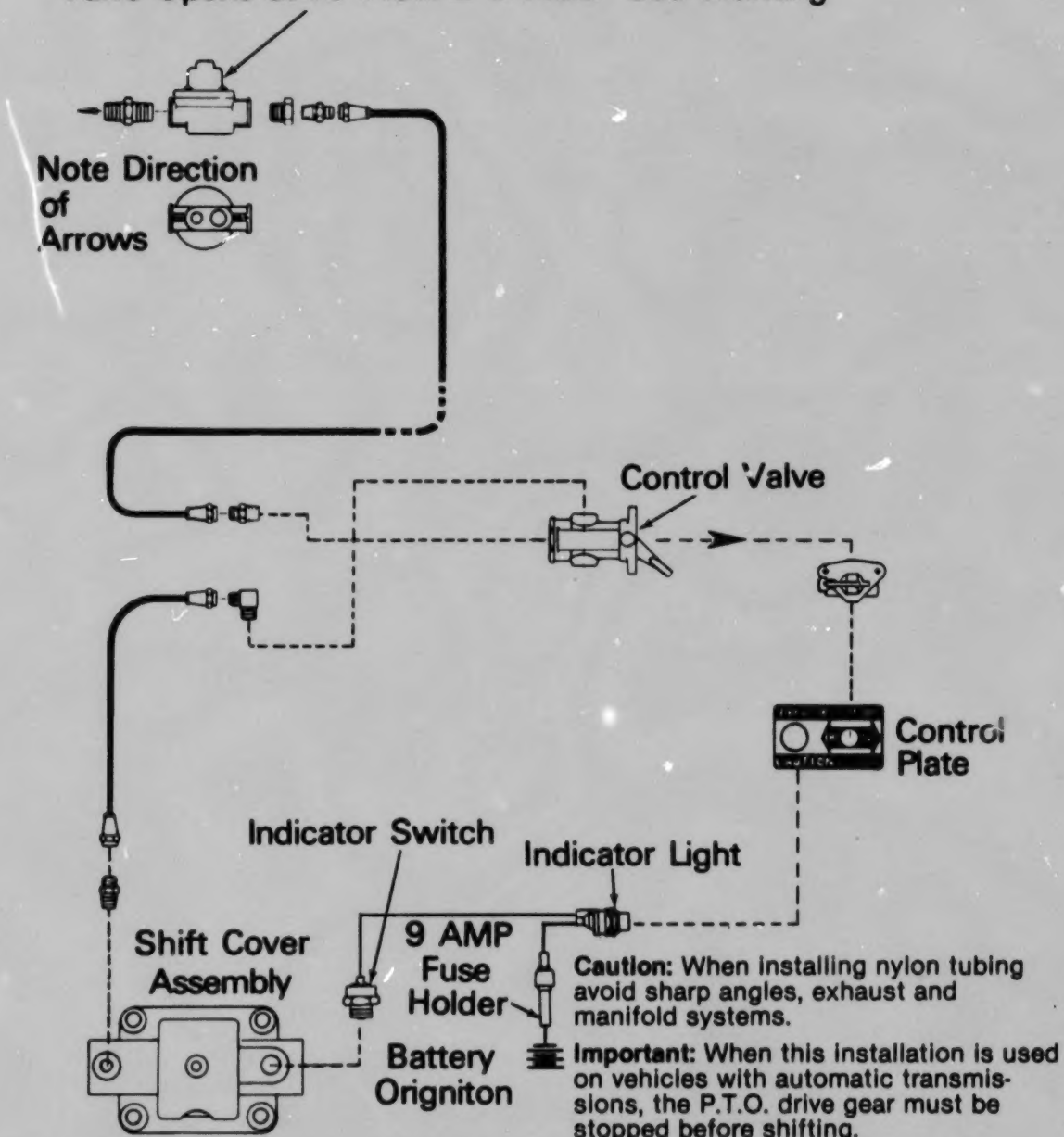
Parts for a PTO Air Shift System

Pressure Requirement

70—140 P.S.I.

Pressure Protection Valve

Valve Opens at 70 P.S.I. $\pm$ 5 P.S.I. See Warning *

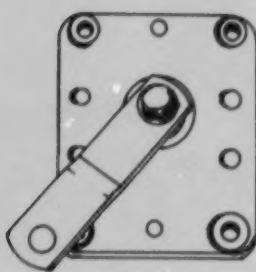


***Warning:** Connect directly to air supply. Do not use tubing between air supply and pressure protection valve.

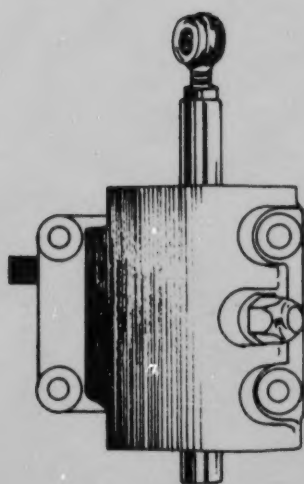
Chelsea PTO component courtesy Drivetrain Service Division, Dana Corporation

TM 5

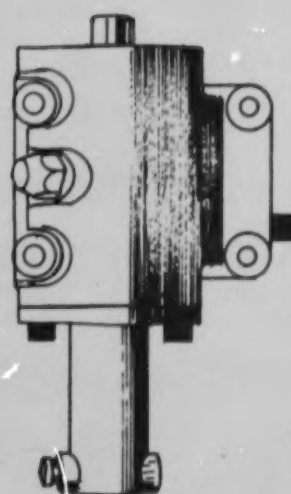
Shift Covers for Transmission-Mounted PTOs



Cable Control



Lever Control



Air Shift

Chelsea shift covers courtesy Drivetrain Service Division, Dana Corporation

POWER TAKE-OFFS
UNIT VIII

JOB SHEET #1--INSTALL A TRANSMISSION-MOUNTED PTO

I. Tools and equipment

- A. Safety glasses
- B. General shop tools
- C. Creeper
- D. Dial indicator
- E. Shop towels
- F. Stud driver
- G. Torque wrench
- H. Drain pan

II. Procedure

- A. Drain oil from transmission
- B. Remove PTO cover plate from transmission
- C. Remove gasket from PTO opening in transmission

(NOTE: Stuff a rag in the opening to prevent dirt from entering transmission.)

- D. Rock drive gear in transmission and driven gear in the PTO

- 1. To show amount of backlash designed in both units
- 2. To establish proper backlash when mounting PTO

- E. Install studs in PTO mount pad on transmission

(NOTE: Where holes are tapped through the transmission case, use Permatex to prevent leaks. Avoid contact of Permatex with automatic transmission fluid in automatic transmissions.)

- 1. Use stud driver
- 2. Torque six bolt studs to 30 - 35 ft. lbs.
- 3. Torque eight bolt studs to 45 - 50 ft. lbs.

JOB SHEET #1

F. Install gaskets on studs

1. Place correct amount of gaskets on studs

(NOTE: Never use gasket sealer between gaskets or on PTO mounting surfaces.)

2. Use gaskets between all mounting surfaces
3. Do not stack more than four gaskets

(NOTE: Usually one thick gasket .020" will be required.)

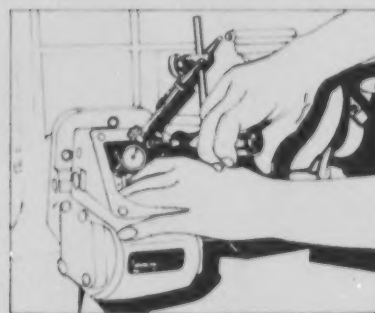
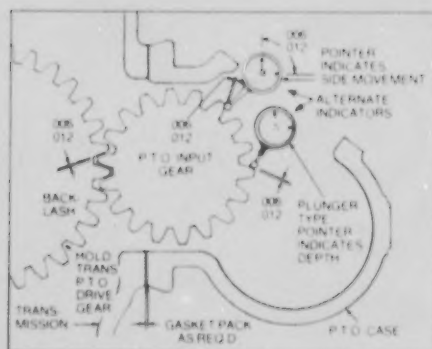
G. Install PTO to transmission

1. Install copper gaskets on studs
2. Install nuts on studs

(NOTE: Copper gaskets are used to prevent oil leaks around studs.)

3. Torque nuts to 30 - 35 ft. lbs. for six bolt PTOs, and 45 - 50 ft. lbs. for eight bolt PTOs
4. Check and adjust backlash
 - a) Remove PTO shift housing or inspection plate
 - b) Mount dial indicator so it measures input gear (driven gear) movement (Figure 1)

FIGURE 1



(Procedure and illustrations for backlash adjustment for Chelsea PTO courtesy Drivetrain Service Division, Dana Corporation)

JOB SHEET #1

5. Hold PTO driver gear in transmission with bar or screwdriver
6. Rock PTO input gear with hand
7. Read amount of backlash on dial indicator
8. Backlash has to be from .006" to .012"
9. Set backlash by adding or removing mount gaskets

(NOTE: A general rule for adding or removing gaskets is that a .010" gasket will change backlash approximately .012". Repeat steps F - G to correct backlash.)

POWER TAKE-OFFS UNIT VIII

NAME _____

TEST

1. Match the terms on the right with their correct definitions.

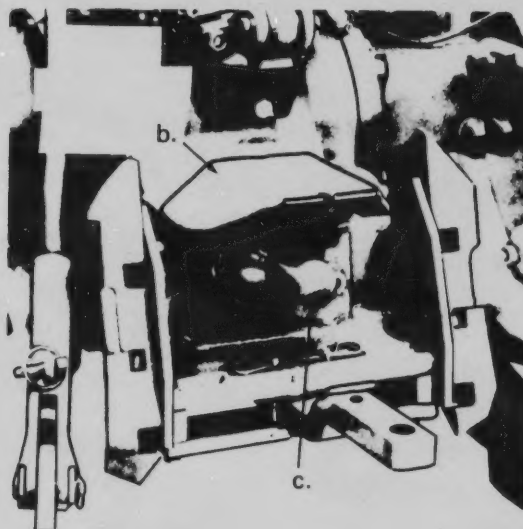
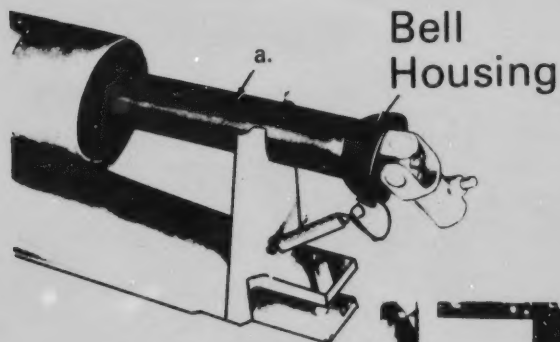
- | | |
|---|----------------------------|
| _____ a. Power take-off | 1. Transmission-driven PTO |
| _____ b. A mechanical device attached to the side of the main transmission or the side or top of the auxiliary transmission; it transmits engine power to auxiliary equipment | 2. PTO |
| _____ c. An attachment in the power train of a machine to drive auxiliary equipment | 3. Independent PTO |
| _____ d. A PTO system having its own clutch control completely separate from the engine clutch and transmission | 4. Tunnel shield |
| _____ e. Operates only when the engine clutch is engaged | 5. Truck application PTO |
| _____ f. A PTO system that has two clutches, one for the transmission and one for the PTO; both are operated by one control | 6. Continuous-running PTO |
| _____ g. Solid shaft with a fixed length and a U-joint at each end | 7. Telescoping shaft |
| _____ h. A shaft with a sliding or telescoping element; can have either two or three U-joints | 8. Spinner shield |
| _____ i. An inverted U-shaped piece of steel which covers the moving parts of a PTO shaft | 9. Tractor PTO |
| _____ j. A cylinder-shaped piece which surrounds the shaft and has a bell housing on each end to cover the U-joints | 10. Solid PTO shaft |

2. Select true statements concerning safe operation of PTOs by placing an "X" in the appropriate blanks.

- _____ a. Keep PTO guards and shields in place
- _____ b. Never engage the PTO while the machine engine is shut off
- _____ c. Keep hands, feet, and clothing away from PTO moving parts
- _____ d. Always connect the PTO when not in use

- _____ e. Never wear loose clothing around PTO in operation
- _____ f. Be sure spinner shields rotate freely
- _____ g. Never attach the PTO drive shaft to the machine PTO shaft
- _____ h. Always disengage the machine PTO and shut off engine before servicing, lubricating, or performing repairs
- _____ i. Always keep nuts and bolts tight on PTO shaft and PTO driven machine
- _____ j. Hook 540 PTO equipment to 1000 rpm PTO equipment with great care
- _____ k. Always block dump beds when working on unit with bed raised

3. Identify three types of PTO guards and shields.



- a. _____
- b. _____
- c. _____

4. List three types of PTO systems.

- a. _____
- b. _____
- c. _____

5. List ASAE-SAE standards for tractor PTO drives.

- a. _____
- b. _____

6. Match complaints on the right with causes for noise, heat, and vibration in transmission-mounted PTOs.

- | | |
|--|----------------------|
| _____ a. Backlash too tight or too loose | 1. Clicking sound |
| _____ b. Worn, nicked, or burred gear; damaged bearing from improper installation | 2. Vibration |
| _____ c. Foreign material in bearing; transmission low on grease | 3. Rattles or whines |
| _____ d. Drive line out of phase; excessive U-joint angle; drive line bent; U-joints worn; PTO loose on transmission; driven equipment loose; worn splines on slip joint | 4. Grinding noise |
| _____ e. PTO installed too tight; low transmission oil level; prolonged stationary use; PTO near exhaust or other heat source; PTO overloaded | 5. PTO running hot |

7. Select true statements concerning troubleshooting PTOs for poor work rate by placing an "X" in the appropriate blanks.

- _____ a. PTO torque rate too high for job being performed
- _____ b. PTO output speed too high or too low for job being done

8. Match complaints on the right with causes for external oil leaks in PTOs.

- | | |
|--|---------------------------------------|
| _____ a. Seal worn from age, heat, or drive line vibration; seal retainer plate installed out of alignment | 1. Leaking housing or mating surfaces |
| _____ b. Porous or cracked housing; broken or worn gasket; 6-bolt idler shaft poor fit; 8-bolt "O" ring not sealing on idler shaft; copper washers needed under 6-bolt PTO mount bolts or nuts; lock washer not under 8-bolt PTO mount bolts; "O" ring leaking on shifting post; elongated mounting bolt holes | 2. Shaft seal leaking |

9. Select true statements concerning troubleshooting PTOs for hard shifting by placing an "X" in the appropriate blanks.

- ☐ a. Backlash too loose
- ☐ b. Tight bend in shift cable
- ☐ c. Gear in backwards
- ☐ d. Tight fit on internal spline of sliding gear causing gear to bind
- ☐ e. Lever linkage needs redesign--not enough mechanical advantage
- ☐ f. Low air pressure for air shift

10. Complete the following list of statements concerning troubleshooting PTOs for jumping out of gear.

- a. Excessive load for PTO torque rating
- b. _____
- c. Shifter poppet spring broken
- d. Shifter poppet spring hole elongated
- e. Shift rail poppet notch worn
- f. Sprung or loose shift fork
- g. _____
- h. Cable or lever linkage not adjusted for full PTO engagement

11. Select true statements concerning troubleshooting power shift PTOs by placing an "X" in the appropriate blanks.

(NOTE: A statement is true only if all parts of a statement are true.)

- ☐ a. Won't engage
 - 1. Improper installation of electric or hydraulic shift circuit
 - 2. Incorrect solenoid valve
 - 3. Transmission oil level low
 - 4. Obstruction in hydraulic shift circuit
 - 5. Clogged hose or screen
 - 6. Inoperative solenoid valve
 - 7. Inoperative electrical switch
 - 8. Bad electrical connection
 - 9. Internal leakage in shifter
 - 10. Clutch plates worn in PTO

_____ b. Will engage but will not operate--system under load

1. Low pressure supplied to PTO
2. Clutch plates worn in PTO

_____ c. PTO will not disengage

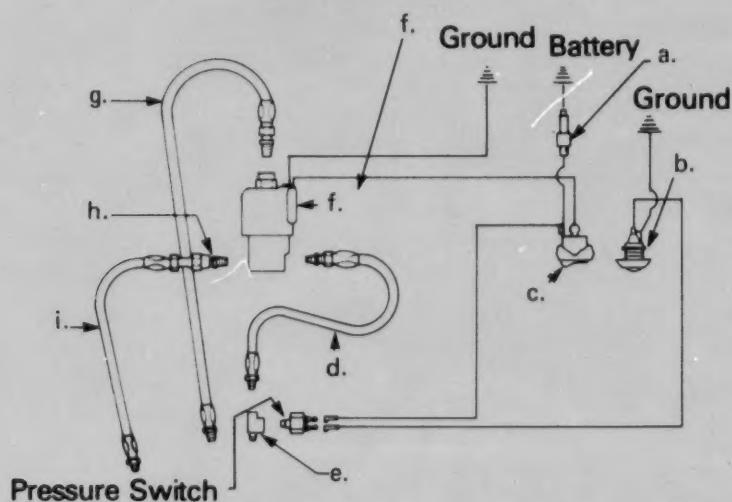
1. Improper installation of circuit
2. Pressure too low
3. Clutch plates in PTO worn

_____ d. Noise, heat, improper work rate, and external oil leaks--Trouble-shooting procedures same as those used with transmission-mounted PTOs

12. List subassembly parts of a two-gear, one-speed PTO.

- a. _____
- b. _____
- c. _____
- d. _____

13. Identify components of hydraulic and electric circuits in a power shift PTO.



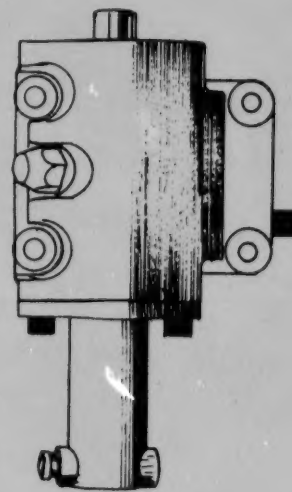
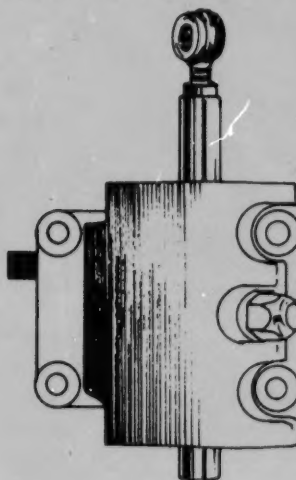
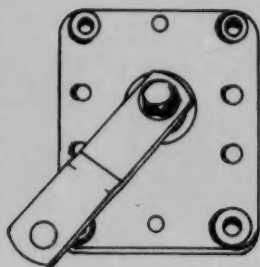
- a. _____
- b. _____
- c. _____
- d. _____

- e. _____
- f. _____
- g. _____
- h. _____
- i. _____

14. List parts of a PTO air shift system.

- a. _____
- b. _____
- c. _____
- d. _____
- e. _____

15. Identify shifter covers for transmission-mounted PTOs.



- a. _____
- b. _____
- c. _____

16. Complete the following list of procedures for lubricating PTO systems.

- a. Check lubricant in transmission
- b. _____
- c. Lubricate slip yoke
- d. _____
- e. Lubricate driven equipment according to manufacturer's recommendations

17. Complete the following list of questions that are relevant when selecting the proper PTO.

- a. What is make and model of transmission?
- b. Which PTO opening will be used?
- c. What accessory will be driven?
- d. How much horsepower is required to drive accessory?
- e. What is the required rotation of PTO?
- f. _____
- g. _____

18. Demonstrate the ability to install a transmission-mounted PTO.

(NOTE: If this activity has not been accomplished prior to the test, ask your instructor when it should be completed.)

POWER TAKE-OFFS
UNIT VIII

ANSWERS TO TEST

- | | | |
|---------|-------|------|
| 1. a. 2 | e. 1 | i. 4 |
| b. 5 | f. 6 | j. 8 |
| c. 9 | g. 10 | |
| d. 3 | h. 7 | |
2. a, b, c, e, f, h, i, k
3. a. Spinner shield
b. PTO master shield
c. PTO shaft guard
4. a. Transmission-driven
b. Continuous-running
c. Independent
5. a. 540 rpm--6 splines on PTO shaft
b. 1000 rpm--21 splines on PTO shaft
6. a. 3
b. 1
c. 4
d. 2
e. 5
7. b
8. a. 2
b. 1
9. b, c, e, f
10. b. Gear teeth worn tapered
g. Air shift pressure low for complete shift
11. a, b, d
12. a. Shift cover assembly
b. PTO case
c. Output shaft and gear assembly
d. Drive gear and shaft assembly
13. a. Nine amp fuse
b. Indicator light
c. Switch
d. Hose from valve to PTO
e. Screen adapter
f. Solenoid valve
g. Dump line back to transmission through PTO
h. Screen adapter
i. Line from transmission to valve

- 14.
 - a. Shift cover assembly
 - b. Indicator switch
 - c. Indicator light
 - d. Control valve
 - e. Pressure protection valve
- 15.
 - a. Cable control
 - b. Lever control
 - c. Air shift
- 16.
 - b. Lubricate U-joints
 - d. Lubricate spinner shield
- 17.
 - f. What is required PTO output shift speed as a percent of engine speed?
 - g. What is the required method of shifting PTO?
- 18. Performance skill evaluated to the satisfaction of the instructor

SPECIAL DRIVES UNIT IX

UNIT OBJECTIVE

After completion of this unit, the student should be able to list types of chains used in special drives, figure their ratios, and discuss chain adjustment, repair, and cleaning. The student should also be able to list types of belts used in special drives, and discuss sheave alignment, gear drives, gear backlash, and troubleshooting techniques for special drives. This knowledge will be evidenced by correctly performing the procedures outlined in the job sheets and by scoring 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms related to special drives with their correct definitions.
2. List three types of chain drives.
3. Complete statements concerning detachable-link chains.
4. Select true statements concerning roller chains.
5. Select true statements concerning silent chains.
6. Complete statements concerning characteristics of detachable-link chains.
7. Select true statements concerning characteristics of standard pitch roller chains.
8. Select true statements concerning characteristics of double pitch roller chains.
9. Complete statements concerning characteristics of silent chains.
10. Complete statements concerning principles of chain drives.
11. Select true statements concerning the alignment of sprocket shafts and sprockets.
12. Select true statements concerning adjustment of chain tension.
13. Complete a list of methods of adjusting chain tension.
14. Identify parts of a chain sprocket.
15. Select true statements concerning stretched chain.

16. Complete statements concerning lubrication of chains.
17. List methods of lubricating chains.
18. Select true statements concerning repair of chain drives.
19. Complete statements concerning cleaning chains.
20. Name three types of belts.
21. Name four factors governing the ability of belts to transmit power.
22. List three forms of belt drive arrangements.
23. Complete measurements of belt sections used on combines.
24. Select true statements concerning adjustable pulleys.
25. Determine the length of a flat belt.
26. Determine the length of a V-belt.
27. Determine pulley sizes and speeds.
28. Select true statements concerning belt tension.
29. Select true statements concerning belt care and maintenance.
30. Complete statements concerning maintenance of pulleys or sheaves.
31. Match types of gear drives with their uses.
32. Complete statements concerning methods of lubricating gears.
33. Select true statements concerning gear backlash.
34. Match types of reciprocating drives with their characteristics.
35. Select true statements concerning maintenance of reciprocating drives.
36. Match hydrostatic drives with their characteristics.
37. Select true statements concerning reversing hydrostatic drives.
38. Complete statements concerning maintenance of hydrostatic drives.
39. Select true statements concerning testing hydrostatic drives.
40. List the functions of a safety release mechanism.
41. Match types of safety release mechanisms with their descriptions.
42. Complete statements concerning maintenance of safety mechanisms.

43. Compute the length of a flat belt.
44. Compute the length of a V-belt.
45. Compute pulley size and speed.
46. Demonstrate the ability to:
 - a. Troubleshoot chain drives.
 - b. Troubleshoot belt drives.
 - c. Troubleshoot gear drives.
 - d. Troubleshoot hydrostatic drives.
 - e. Troubleshoot safety mechanisms.

SPECIAL DRIVES UNIT IX

SUGGESTED ACTIVITIES

- I. Provide student with objective sheet.
- II. Provide student with information and job sheets.
- III. Make transparencies.
- IV. Discuss unit and specific objectives.
- V. Discuss information sheet.
- VI. Demonstrate and discuss the procedures outlined in the job sheets.
- VII. Show films covering special drives, especially a safety film.
- VIII. Take students on field trip to a shop that works on special drives.
- IX. Have a person from a manufacturer of special drives present a program to the class.
- X. Give test.

INSTRUCTIONAL MATERIALS

- I. Included in this unit:
 - A. Objective sheet
 - B. Information sheet
 - C. Transparency masters
 1. TM 1--Detachable-Link Chain
 2. TM 2--Roller Chains
 3. TM 3--Silent Chain
 4. TM 4--Determining Pitch on Roller Chains
 5. TM 5--Alignment and Misalignment of Sheaves
 6. TM 6--Reciprocating Drives
 7. TM 7--Reciprocating Drives (Continued)
 8. TM 8--Standard Cross-Sectional Dimensions of V-Belts
 9. TM 9--Belt Creep

10. TM 10--Pintle Chain
11. TM 11--Parts of a Chain Sprocket
12. TM 12--Belt Drive Arrangements
13. TM 13--Typical Belt Sections Used on Combine
14. TM 14--Adjustable Pulleys
15. TM 15--Determining the Length of a Flat Belt
16. TM 16--Determining the Length of a V-Belt
17. TM 17--Determining Pulley Sizes and Speeds
18. TM 18--Hydrostatic Drive
19. TM 19--Hydrostatic Drives
20. TM 20--Safety Release Mechanisms
21. TM 21--Safety Release Mechanisms (Continued)

D. Assignment sheets

1. Assignment Sheet #1--Compute the Length of a Flat Belt
2. Assignment Sheet #2--Compute the Length of a V-Belt
3. Assignment Sheet #3--Compute Pulley Size and Speed

E. Answers to assignment sheets

F. Job sheets

1. Job Sheet #1--Troubleshoot Chain Drives
2. Job Sheet #2--Troubleshoot Belt Drives
3. Job Sheet #3--Troubleshoot Gear Drives
4. Job Sheet #4--Troubleshoot Hydrostatic Drives
5. Job Sheet #5--Troubleshoot Safety Mechanisms

G. Test

H. Answers to test

II. References:

- A. *Fundamentals of Service: Power Trains*. Moline, IL 61265: John Deere Service Publications, Dept. F, 1972.
- B. Notgrass, Troy. *The Automotive Power Train Mechanic*. Austin, TX: Instructional Materials Service Division of Extension, The University of Texas at Austin, 1973.

SPECIAL DRIVES
UNIT IX

INFORMATION SHEET

I. Terms and definitions

- A. Detachable-link chain--A series of formed links, either open or closed, which can be detached and are either malleable cast iron or pressed steel (Transparency 1)

(NOTE: Detachable-link chains are also called plain chains.)

- B. Roller chain--Made up of alternate roller links and pin links with pins and free rolling bushings (Transparency 2)

- C. Silent chain--A series of flat metal links, with a tooth shape at each end, connected by pins to form a flexible continuous chain (Transparency 3)

- D. Chain pitch--Distance from the center of one pin to the center of the next pin

- E. Sprocket pitch--Distance between one point on a sprocket tooth and the corresponding point on the next tooth

- F. Alignment--Adjusting or positioning parts to bring into line (Transparency 5)

- G. Misalignment--When bearings are not on the same center line with good functional or working limits (Transparency 5)

- H. ID--Inside diameter

- I. OD--Outside diameter

- J. FPM--Feet per minute

- K. Reciprocating drives--Drives that change a rotary motion to a linear motion (mowing cutter bars) (Transparencies 6 and 7)

- L. Tension--Effort which elongates or stretches a material

- M. Flat belt--A belt of flat construction used where pulleys are far apart and high power is needed for a separate machine (old threshers or sawmills)

- N. V-belt--A belt of V construction used for driving light loads between short-range pulleys; the load is carried on the sides of the belt

- O. Arc--Contact (or wrap) between belt and pulley (Transparency 9)

- P. Belt slip--Slight loss of speed between the drive and driven pulleys

INFORMATION SHEET

- Q. Belt creep--The slight stretching of the belt as it runs over the pulley (Transparency 9)

(NOTE: The words "sheave" and "pulley" mean the same thing.)

- R. Hydrostatic drive--A drive using fluid under pressure to transmit engine power to the driven unit (Transparency 18)

- S. Gear drive--Type of drive in which a system of gear arrangement is used to transmit power

(NOTE: When two gears are in mesh, all slippage is gone; for this reason, gears are widely used for high power applications.)

- T. Displacement--The quantity of fluid a pump can move during each revolution

II. Types of chain drives

- A. Detachable-link chain
- B. Roller chain
- C. Silent chain

III. Detachable-link chains (plain chain) (Transparency 1)

- A. Series of formed links (closed or open)
- B. Detachable links
- C. Larger plain chains are of pintle construction (Transparency 10)
- D. Low speed use (conveyors or drags)
- E. Open plain chains used in light loads
- F. Closed pintle chains used in heavier loads

IV. Roller chains (Transparency 2)

- A. May be installed in multiple strands for heavier loads
- B. Have less vibration than plain chains
- C. Good for low to medium speed heavy loads with sprockets far apart
- D. Made up of pin bushing and roller for less wear
- E. Two types of roller chains, single pitch and double pitch

INFORMATION SHEET

- V. Silent chains (Transparency 3)
 - A. Sprockets are similar to gears in appearance
 - B. Quieter operation and less vibration
 - C. Can operate at higher speeds
 - D. Some have links with teeth on both sides so that over-and-under drives can be used (serpentine drives)
 - E. Used as timing chains
- VI. Characteristics of detachable-link chains
 - A. Used at speeds up to 500 RPM
 - B. Low in cost
 - C. Ideal for conveyor or elevator work
 - D. Provide better wear under dirty conditions
 - E. Malleable cast iron chain more resistant to corrosion than steel (pintle)
 - F. Pressed steel has lower initial cost
- VII. Characteristics of standard pitch roller chains
 - A. Satisfactory at speeds of 100 FPM to 4500 FPM depending on pitch
 - B. As speed increases the pitch must be decreased
 - C. May be 98 to 99 percent efficient under ideal conditions
 - D. Oil bath lubrication desired for high speed drives
 - E. Sprockets may be driven from either side of roller chain
- VIII. Characteristics of double pitch roller chains
 - A. Satisfactory for small sprocket speeds of up to 600 RPM
 - B. Similar to standard pitch roller chains except is twice the pitch of standard chain
- IX. Characteristics of silent chains
 - A. More satisfactory at higher speeds than roller chains
 - B. Have practically no sliding action
 - C. Most commonly used in final drives of tractors and transfer cases for four wheel drive vehicles

INFORMATION SHEET

X. Principles of chain drives

- A. Chain drives consist of one or more sprockets and an endless chain
- B. The links of the chain mesh with the teeth of the sprocket and maintain a constant speed ratio between drive and driven sprockets
- C. Sprockets on the same side of a chain turn in the same direction
- D. Sprockets on the opposite side of the chain turn in opposite direction
- E. Sprockets should always be no smaller than ten teeth to prevent excessive wear
- F. If the chain has even number of pitches, the sprockets have to have an odd number of teeth or vice versa

(NOTE: If pitches and teeth are both odd or even, it will cause uneven wear and vibration.)

- G. The smaller the sprocket, the more wear on chain and sprocket

(NOTE: On small sprockets the chain bends more causing more wear on chain and the small sprocket turns more R.P.M. than the larger sprocket causing more wear on smaller sprocket.)

XI. Alignment of sprocket shafts and sprockets (Transparency 5)

- A. Level each shaft with machinist's level or protractor
- B. Align all shafts parallel to each other by making sure the distance between the shafts is equal on both sides of the sprockets
- C. Align sprockets with straight edge on the finished surfaces on the sides of the sprockets

XII. Adjustment of chain tension

- A. Horizontal and inclined drives
 - 1. The chain sag should be about $1/4$ " per foot between shaft centers
 - 2. All slack should be on one side
- B. Vertical drives, and shock loading or reversible rotation drives' chains should be almost taut

XIII. Methods of adjusting chain tension

- A. Moveable sprocket shafts
- B. Adjustable idler sprockets
- C. Adjustable shoe

INFORMATION SHEET

XIV. Parts of a chain sprocket (Transparency 11)

- A. Tooth height
- B. Tooth thickness
- C. Tooth width
- D. Point width
- E. Tooth face
- F. Base circle
- G. Pitch circle
- H. Outside circle

(NOTE: Base circle, pitch circle, and outside circle are imaginary terms used to define movement and are not physically parts of a chain sprocket.)

XV. Stretched chain

- A. Adjuster has reached end of travel
- B. Chain begins to ride on the tips of the sprocket teeth

(NOTE: If adjuster has reached the end of its travel, and chain still fits sprocket, remove chain links and readjust to proper tension.)

XVI. Reasons for lubrication of chains

- A. Reduces wear
- B. Protects against corrosion
- C. Prevents galling
- D. Prevents seizing of pins and bushings

XVII. Methods of lubricating chains

- A. Manual lubrication

(CAUTION: Never manually lubricate a chain that is moving.)

1. Applied with brush on chain
2. Applied with spout can

(NOTE: Lubricate every eight hours or when oil starts to discolor between joints; manufacturer's specifications for lubrication should be followed carefully.)

INFORMATION SHEET

- B. Drip lubrication
 - 1. Oil drops are directed between the link plates
 - 2. Oiling should be sufficient to prevent discoloration of oil between joints
- C. Oil bath lubrication
 - 1. Lower strand of chain runs through a sump of oil
 - 2. Oil level should reach pitch line of chain at its lowest operating level
- D. Disc lubrication
 - 1. Chain runs above oil level in sump
 - 2. Disc rotates and picks up oil and deposits it onto the chain by means of a trough or collector plate
- E. Oil stream lubrication
 - 1. Lubrication is supplied by a pump onto chain through a nozzle
 - 2. Excess returns back to pump
 - 3. Properly lubricated chains will not show a brownish color at joints and connecting link pins will be brightly polished

XVIII. Repair of chain drives

- A. Grind off heads of link pins or remove keys
- B. Drive out the two pins of the link evenly
(NOTE: A chain-breaking tool is an efficient method of removing links.)
- C. Reverse sprockets, if design permits
(NOTE: Reversing sprockets can increase sprocket life.)
- D. Do not install new chain on worn sprockets
- E. Do not add new chain links to worn chain

XIX. Cleaning chains

- A. Wash chain in cleaning solvent
- B. Drain and dry chain
- C. Soak chain in oil
- D. Hang chain to let excess oil drain off

INFORMATION SHEET

XX. Types of belts

- A. Flat belt
- B. V-belt
- C. Round belt
- D. Polygrooved or ribbed belt

XXI. Factors governing the ability of belts to transmit power

- A. Tension of belt
- B. Friction of belt to pulley

(NOTE: Type of material belt and pulley are made of help determine the amount of friction.)

- C. Speed of belt

(NOTE: The higher the speed, the less contact and friction between belt and pulley.)

- D. Belt wrap on pulley

(NOTE: The more wrap on a pulley, the more area for friction contact.)

XXII. Belt drive arrangements (Transparency 12)

- A. Open
- B. Turned
- C. Crossed
- D. Serpentine
- E. Mule

XXIII. Belt sections used on combines (Transparency 13)

- A. $1/2 \times 5/16$
- B. $21/32 \times 13/32$
- C. $7/8 \times 17/32$
- D. $1 \ 1/4 \times 3/4$
- E. $1 \ 3/4 \times 25/32$
- F. $2 \ 1/4$ flat 12 ribs

INFORMATION SHEET

XXIV. Adjustable pulleys (Transparency 14)

- A. Used to adjust belt tension
- B. Used to change belt speed
 - 1. Moving belt in on drive pulley and out on driven pulley decreases speed of driven pulley
 - 2. Moving belt out on drive pulley or in on driven pulley increases driven pulley speed

XXV. Determining the length of a flat belt (Transparency 15)

- A. Add together the diameters of the two pulleys
- B. Divide the sum by two and multiply the quotient by three
- C. To this product, add twice the distance between the centers of the two pulley shafts

Example: 1. $8'' + 4'' = 12''$
 2. $12'' \div 2 = 6''$ and $6'' \times 3 = 18''$
 3. $18'' + 18'' + 18'' = 54''$ length of belt

XXVI. Determining the length of a V-belt (Transparency 16)

- A. Symbols
 - 1. L = Length of belt
 - 2. C = Distance between centers of sheaves
 - 3. D = Outside diameter of large sheaves
 - 4. d = Outside diameter of small sheaves

- B. Formula-- $L = 2C + 1.75(D + d) + \frac{(D - d)}{4C}$

Example: C = 18" D = 8" d = 4"

$$L = 2(18'') + 1.75(8 + 4) + \frac{8 - 4}{4(18)}$$

$$L = 36 + 1.75(12) + \frac{4}{72}$$

$$L = 36 + 21 + .055$$

$$L = 57.055$$

INFORMATION SHEET

XXVII. Determining pulley sizes and speeds (Transparency 17)

A. Symbols

1. D = Diameter of driver pulley
2. S = Speed of driver pulley
3. d = Diameter of driven pulley
4. s = Speed of driven pulley

B. Formula-- $D \times S = d \times s$

Example: $D = 2''$ $S = 1000 \text{ RPM}$ $d = 6''$

$$s(6) = 2(1000)$$

$$s = \frac{2000}{6}$$

$$s = 333.33 \text{ RPM}$$

XXVIII. Belt tension

A. Results of too little tension

1. Broken belt
2. Burned spots
3. Excessive cover wear
4. Overheating of belt and pulley

B. Results of too much tension

1. Belt heating
2. Excessive stretch
3. Damage to bearings in drive and driven units
4. Damage to pulleys

C. Correct tension on V-belt

1. Belt should show springiness when hit with the hand
2. Belts should not vibrate like a rubber band

INFORMATION SHEET

3. Properly adjusted, a belt should deflect about one thickness of the belt at a point midway between sheaves

(NOTE: Belt tension should always be set according to manufacturer's specifications.)

4. Belt should be readjusted after 1 hour of operation and checked periodically

(NOTE: Initial belt seating and stretch occurs during first 24 hours of operation.)

XXIX. Belt care and maintenance

A. Problems caused by oil and grease and their solutions

1. Causes belts to become soft
2. Causes belts to slip
3. Clean with soft cloth soaked in solvent

B. Problems caused by heat over 120° F

1. Belts may harden
2. Belts may crack
3. Belts may stretch

(NOTE: Be sure to keep belts ventilated properly by keeping shields and screens clean.)

C. Matching of belts

1. If one belt in a set needs replaced, replace all belts in that set
2. Never use belts manufactured by different companies in the same set

D. A belt should seat 1/16" above or below outer edge of sheave

XXX. Maintenance of pulleys or sheaves

A. Worn sheave grooves can be caused by:

1. Dust
2. Corrosion from moisture and chemicals in the air

(NOTE: When sheaves grooves are worn 1/32" or more, the sheave should be repaired, regrooved, or replaced.)

INFORMATION SHEET

B. Shiny sheave groove bottom can be caused by:

1. Worn belt
2. Worn sheave
3. Wrong sheave
4. Wrong belt

(NOTE: Shiny sheave bottom groove is caused by belt bottoming in sheave groove.)

C. Wobbling sheaves can be caused by:

1. Bent shaft
2. Bent sheave
3. Worn or damaged shaft bearings

(NOTE: A wobbling sheave should be corrected at once to prevent belt or unit damage.)

4. Worn bore in sheave

XXXI. Types of gear drives

A. Screw gears

1. Used in screw jacks
2. Used in machine feed

B. Bevel gears

1. Used to change direction (hand crank controls)
2. Used in ring gear and pinion (rear axle, right angle drives)

C. Worm gears (screw)

1. Used in steering gears
2. Used in winch drives
3. Used in applications with high speed input and low speed output

INFORMATION SHEET

XXXII. Methods of lubricating gears

(NOTE: Gear drives require many types of lubrication from simple oils to complex formulas. For type of lubricants to use, consult manufacturer's operator's manual.)

- A. Splash pan, which the gears run through
- B. Hand lubrication by brushing or squirting lubricant on gears
- C. Automatic lubrication by drip oiler
- D. Forced lubrication by means of a pump

XXXIII. Gear backlash

- A. Too much gear backlash, the clearance or play between two gears, can be caused by any of the following:
 - 1. Worn gears
 - 2. Improper meshing of teeth
 - 3. Worn bearings
 - 4. Improper bearing adjustment
- B. Too much backlash results in severe gear teeth impact causing damage to gear teeth
- C. Gear backlash is adjusted either by shims or by bearing preload
- D. Gear backlash in some cases is preset at manufacture by gear and bearing arrangement

(NOTE: Always set gear backlash according to manufacturer's service manual.)

XXXIV. Types of reciprocating drives and their characteristics

(NOTE: A reciprocating mechanism is not actually a drive but is a supplement or helper for the drive.)

- A. Crankwheel and lever (Transparency 6)
 - 1. Crankwheel has lever mounted off center
 - 2. As wheel turns one revolution, lever makes two strokes

(NOTE: A mower cutting bar is an example of a machine using this principle.)

INFORMATION SHEET

B. Crankarm and lever drive (Transparency 7)

1. Operates like a crankshaft and rod assembly in an engine
2. Has a flywheel or counterbalance to offset the inertia of the sudden changes in direction
3. The direction of the counterbalance is always the opposite of the pitman or lever

(NOTE: The plunger head in a hay bailer is driven by a crankarm and lever assembly.)

C. Cam drives (Transparency 6)

1. Change rotary motion to reciprocating motion by use of a cam and cam follower
2. Cam follower always returns to the same starting point
3. Action may be simple direct motion, complicated motion, or delayed motion
4. Cam drives may use a spring load, gravity, or a track to return them to their starting position

XXXV. Maintenance of reciprocating drives

A. Lubrication is the key to good operation of all mechanical drives; any moving part that contacts another part should be lubricated

B. Points of maintenance

1. Bearings should be kept lubricated and checked for wear or damage periodically
2. Cam tracks or cam surfaces require greasing for smooth operation and minimum wear
3. Hinged areas need lubrication
4. Enclosed drives should have oil level checked periodically
5. Refer to machine operator's manual for proper lubrication periods and type of lubricants

XXXVI. Hydrostatic drives (Transparency 18)

A. Fixed displacement pump with fixed displacement motor (Transparency 19)

1. Constant input speed gives constant horsepower and torque at the output

INFORMATION SHEET

2. Input speed varies; output horsepower and speed will vary, but torque will remain the same
 3. When both pump and motor are fixed displacement they act as a gear drive
- B. Variable displacement pump with fixed displacement motor (Transparency 19)
1. Pump output is variable, motor output speed is variable and torque output is constant for any given pressure
 2. This type drive gives variable speed and constant torque
- C. Fixed displacement pump with variable displacement motor (Transparency 19)
1. Output speed controlled by changing the motor displacement
 2. Motor displacement decreases, output speed increases, and torque decreases
 3. When balanced, constant horsepower output is obtained
- D. Variable displacement pump with variable displacement motor (Transparency 19)
1. Output of both constant torque and constant horsepower (torque X speed = horsepower)
 2. Most flexible drive but also is the most difficult to control

XXXVII. Reversing hydrostatic drives

- A. Reversing output shaft of motor can be done by shifting either the pump or motor swashplates
- B. In neutral, the swashplate is vertical and no oil is pumped
- C. In forward, the swashplate is tilted and oil is pumped in one direction
- D. In reverse, the swashplate is tilted the opposite way and oil is pumped the opposite direction reversing the motor output

(NOTE: The pump drive shaft always rotates clockwise, but the motor drive shaft can rotate in either direction, depending on the direction of the oil flow from the pump.)

INFORMATION SHEET

XXXVIII. Maintenance of hydrostatic drives

A. Clean unit before removing components

1. Steam clean complete area around component to be worked on
2. If steam cleaning is unavailable, use a cleaning solvent

(NOTE: Never use paint thinner, gas, or acetone to clean the area to be worked on; they are fire hazards and could damage hoses.)

3. Prevent water from entering system when steam cleaning

B. Precautions to take before repairing pump or motor

1. Seal all lines and fittings with plastic bags or plugs as lines are removed
2. Have a container of clean solvent to wash parts in
3. Have clean, dust free work area
4. Have a container of clean transmission fluid to lubricate parts as they are assembled
5. Have a container of clean petroleum jelly to lubricate surfaces where needed

(NOTE: Internal service on either the pump or motor must be done under extremely clean conditions. The tolerances in these units are similar to those in diesel injection pumps and equal care must be taken.)

6. Have new o-rings and gaskets
7. Have new or clean oil for system

XXXIX. Testing hydrostatic drives

- A. Test charging and operating oil pressures
- B. Test for oil flow rate and oil temperature
- C. Use the proper test equipment and procedures as given in the machine technical manual

XL. Functions of a safety release mechanism

(NOTE: In a machine where one power source drives several work functions and each function has a different work load, a torque limiting factor or safety release mechanism is placed in the power line to prevent damage in case an obstruction enters the machine.)

- A. Relieves shock on the power source
- B. Protects machine doing the work

INFORMATION SHEET

XLI. Types of safety release mechanisms and their descriptions

A. Slip clutches (Transparency 20)

1. Installed in drive line
2. Works by means of friction discs and springs
3. Obstruction in machine overcomes friction clutch facings, preventing damage to machine
4. Tension can be adjusted at the springs

B. Jump clutches (Transparency 21)

1. Installed in drive line
2. Have ratchet teeth and spring tension
3. In case of overload, the spring tension is overcome and ratchet slips, disengaging the power train
4. Tension should be adjusted at spring

C. Shear pin (Transparency 21)

1. Works on stress principle
2. The harder the pin the more force it takes to shear
3. When an obstruction enters the machine, the pin will shear, protecting the machine
4. Shear pins are inexpensive
5. When pin shears, the machine is inoperative until pin is replaced

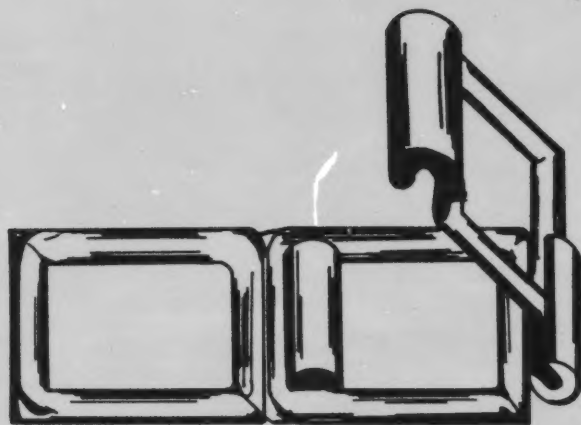
XLII. Maintenance of safety mechanisms

A. Lubrication of safety mechanisms

1. Light coat of oil on faces of clutches to prevent sticking
2. Too much oil causes slipping
3. Lubricate springs
4. Lubricate shafts where they come together

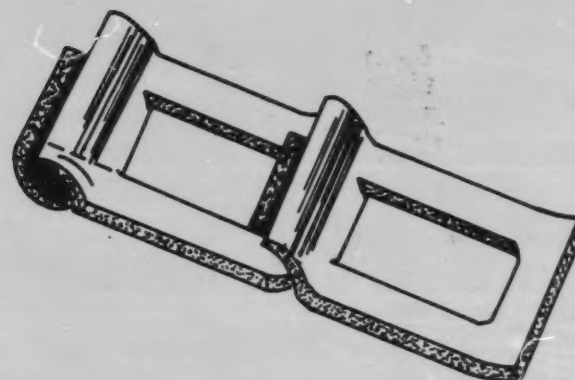
B. Follow machine specifications for adjustment of safety mechanisms and proper shear pins

Detachable-Link Chain



Malleable Cast Iron

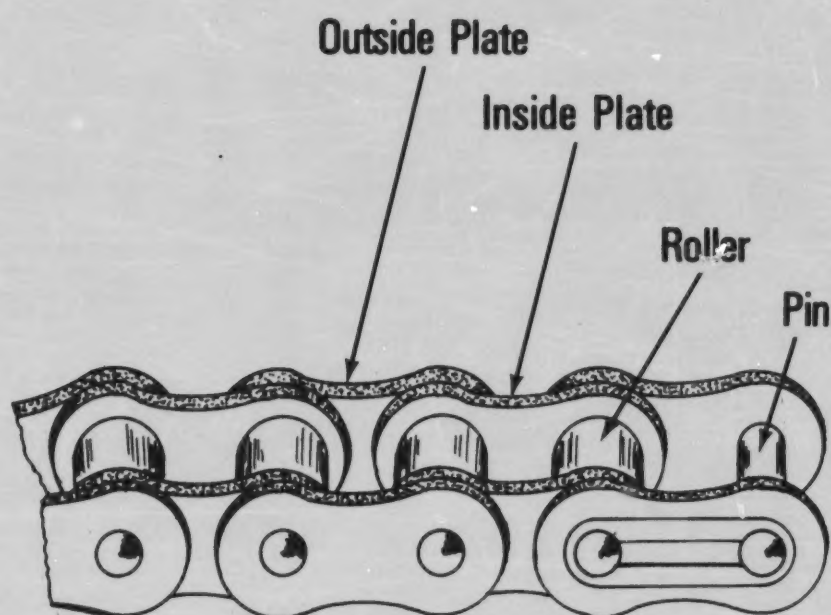
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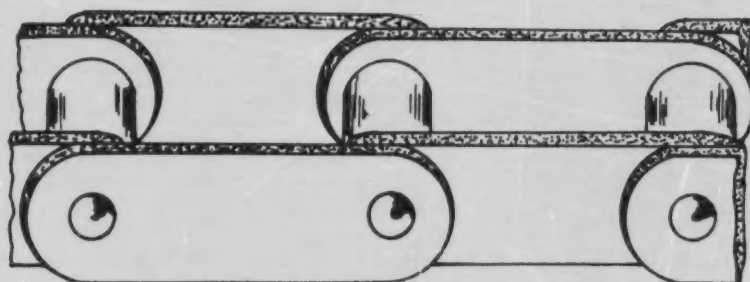
Pressed Steel

727

Roller Chains

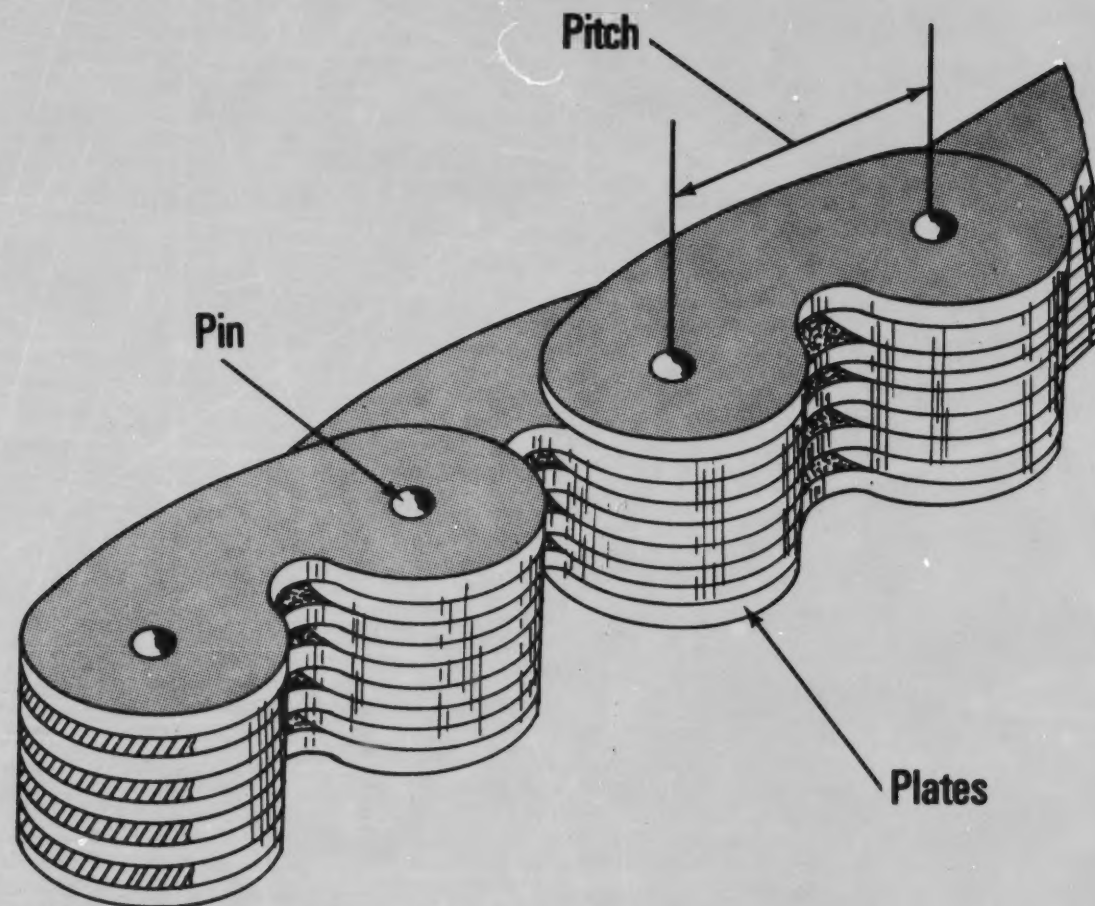


Standard Pitch

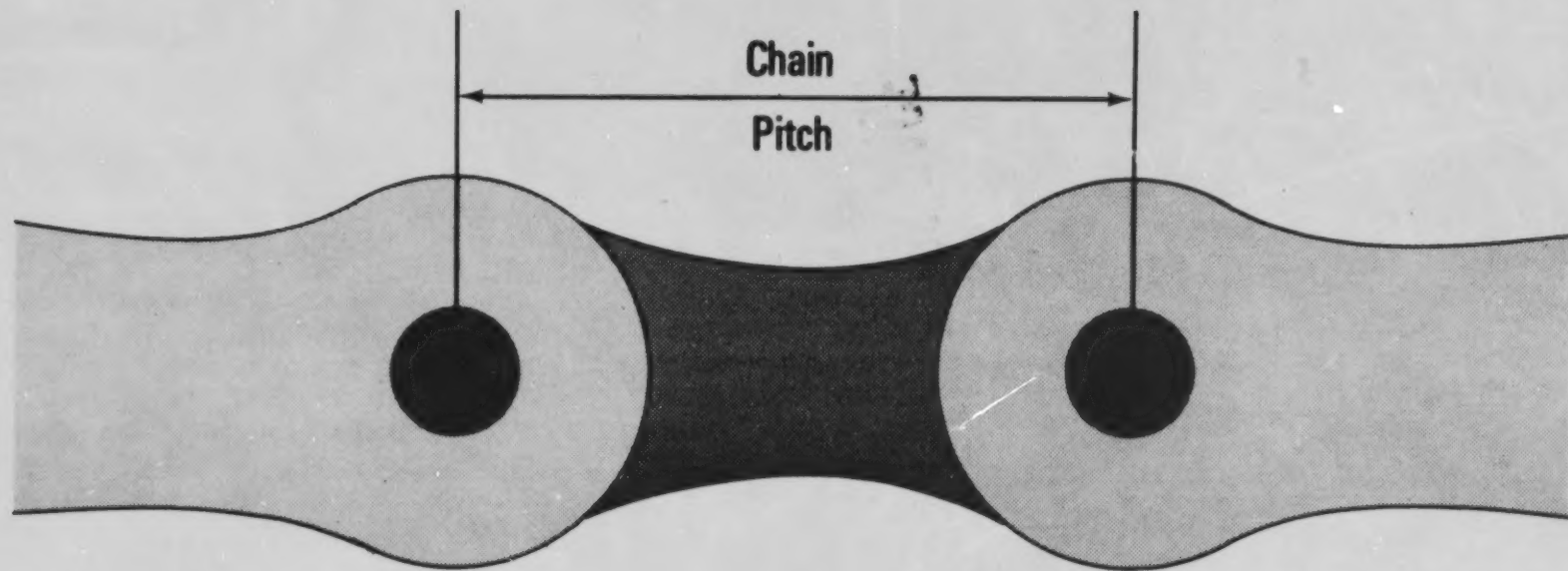


Double Pitch

Silent Chain



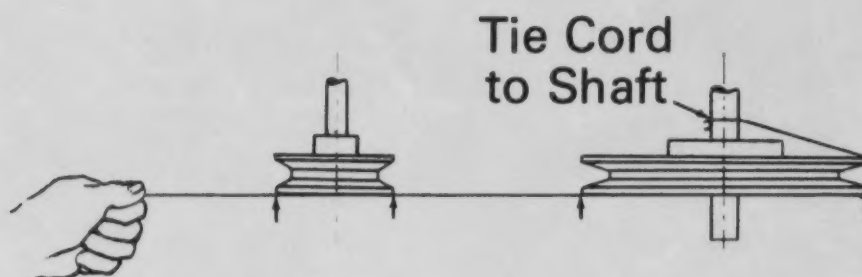
Determining Pitch on Roller Chains



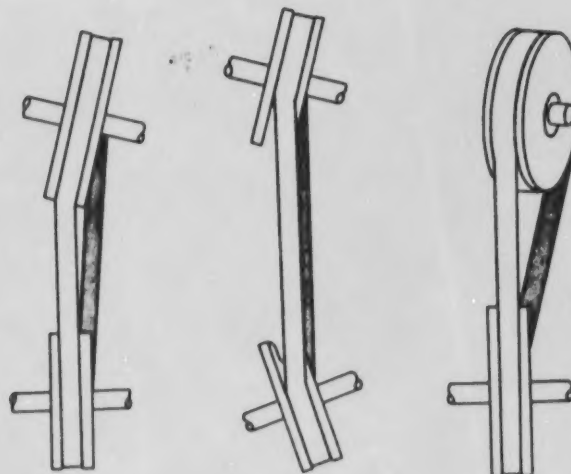
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Alignment and Misalignment of Sheaves

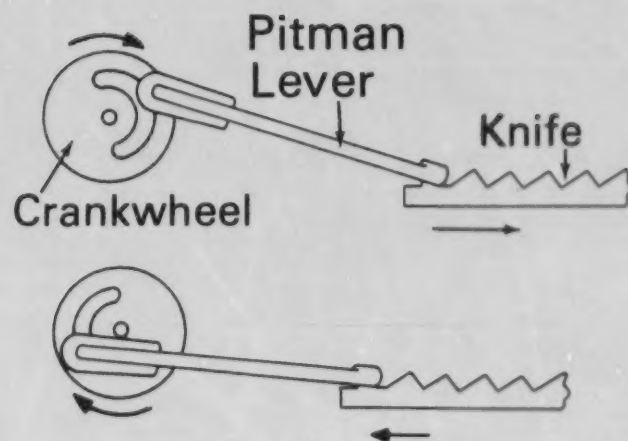


Belt pulleys are in alignment when cord touches sheaves at points indicated by arrows.

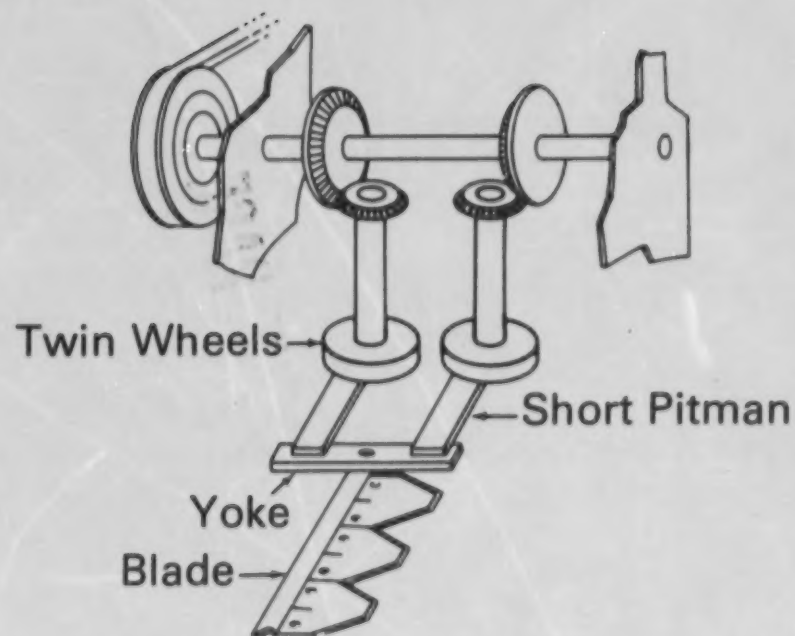


Pulleys misaligned can damage V-belt.

Reciprocating Drives



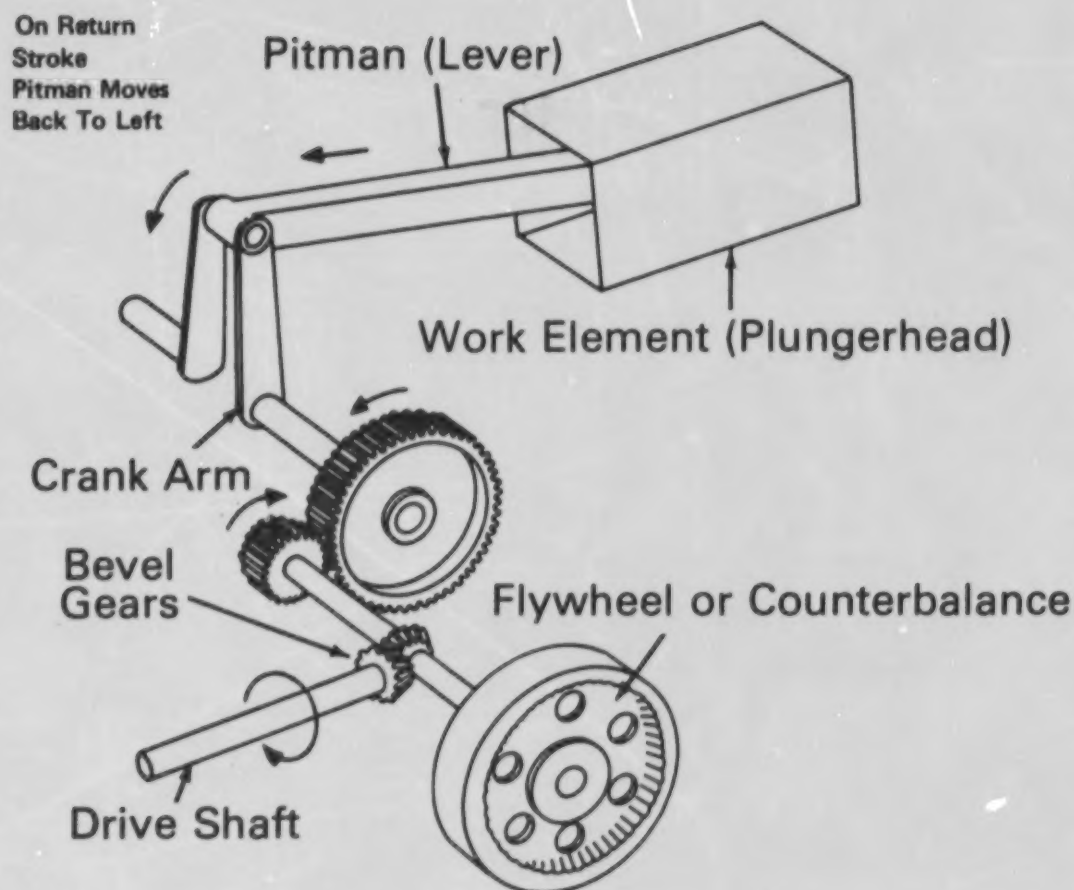
Crankwheel and Pitman Lever Driving Mower Blade



Twin Wheel Drive Operating Mowing Cutter Bar

Reciprocating Drives

(Continued)

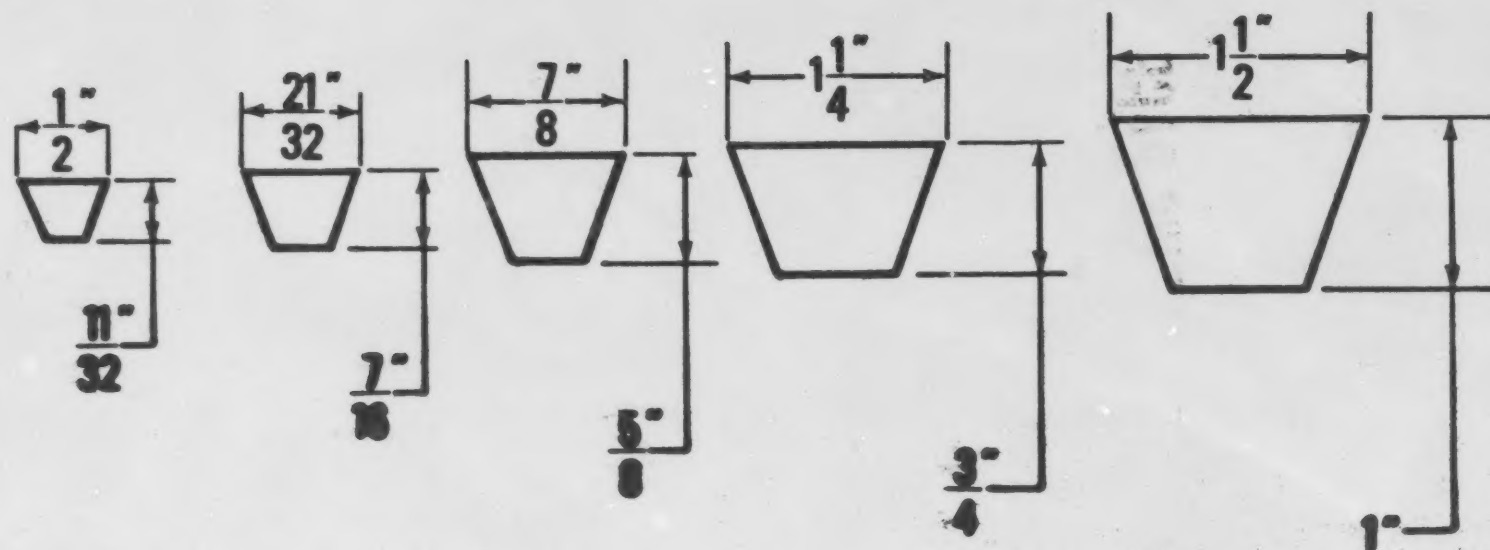


Crankarm and Lever Drive For Hay Baler Plungerhead

736

Courtesy DEERE & CO., MOLINE, IL

Standard Cross-Sectional Dimensions of V-Belts



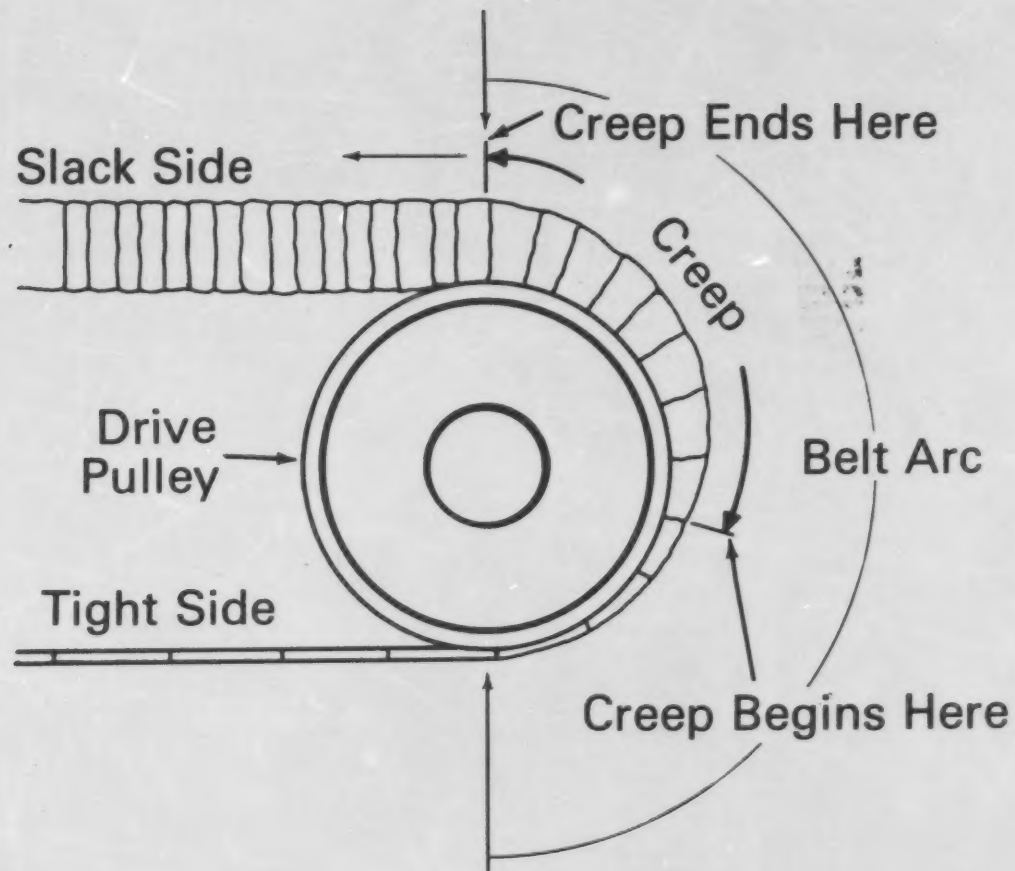
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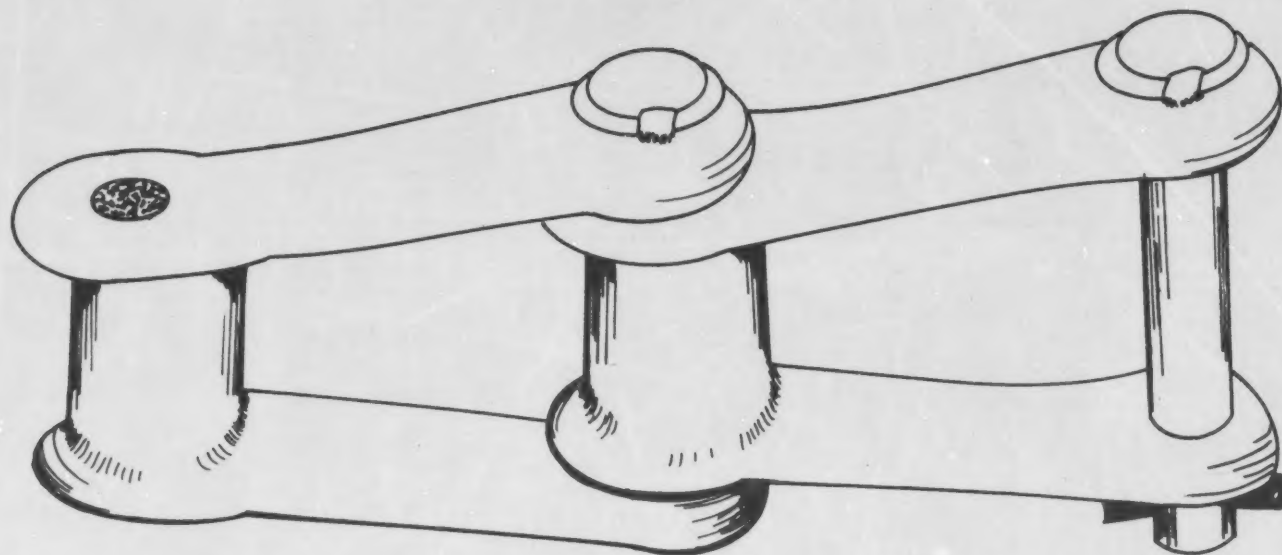
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TM 8

Belt Creep



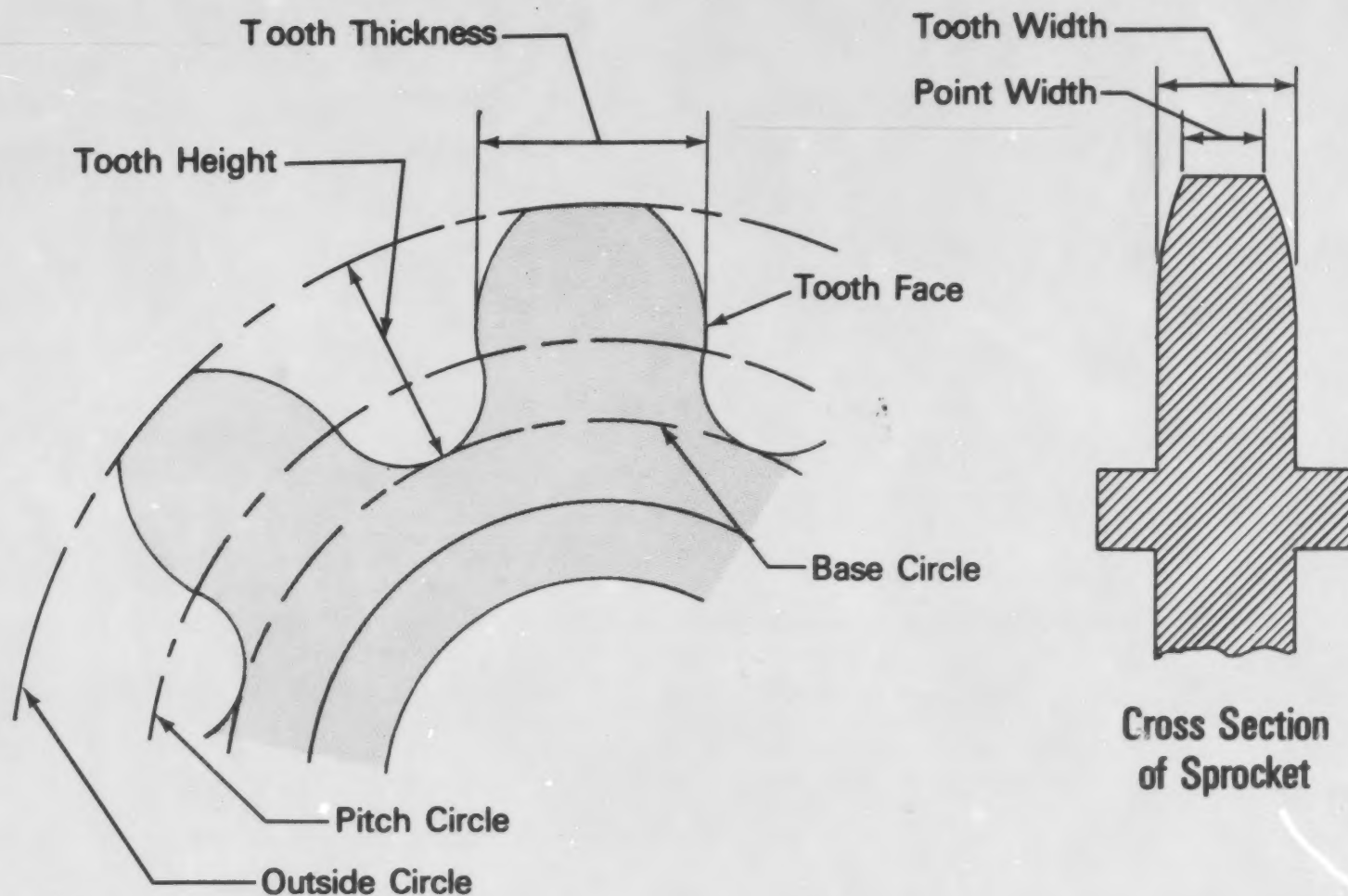
Pintle Chain



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742

Parts of a Chain Sprocket



Belt Drive Arrangements



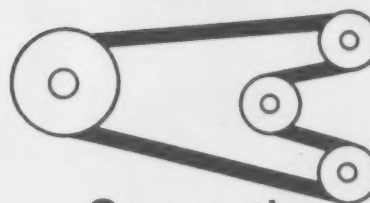
Open



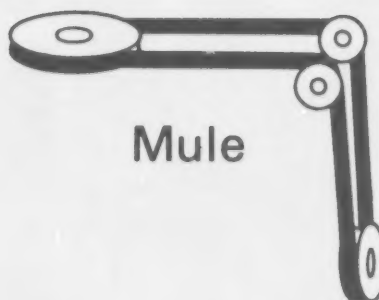
Crossed



Turned



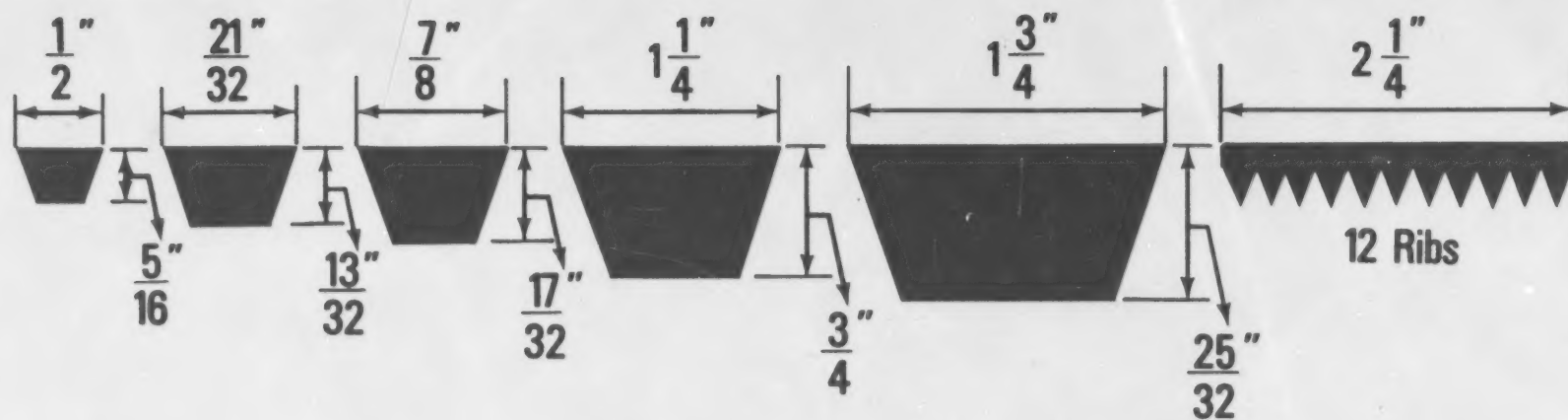
Serpentine



Mule

715

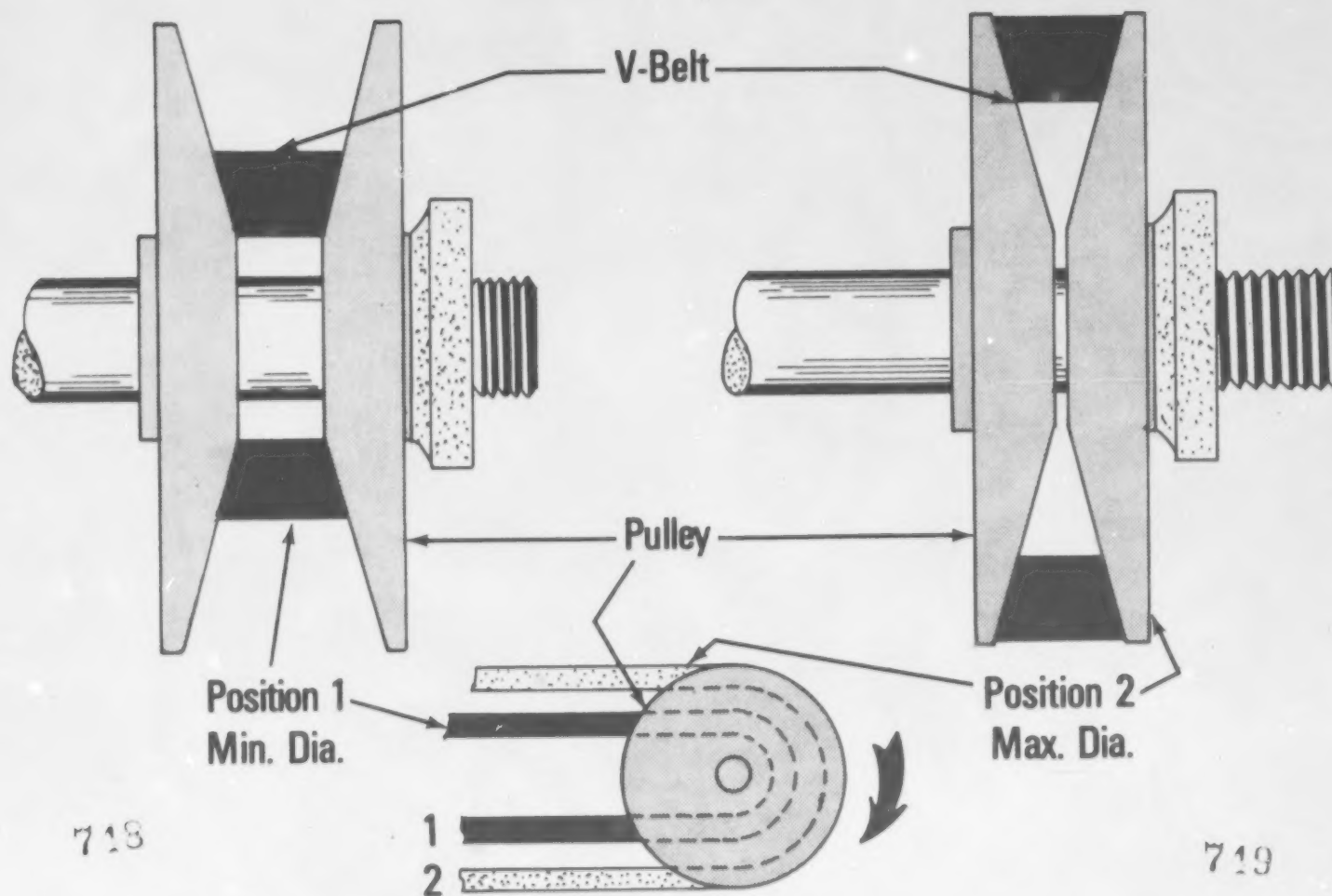
Typical Belt Sections Used on Combine



716

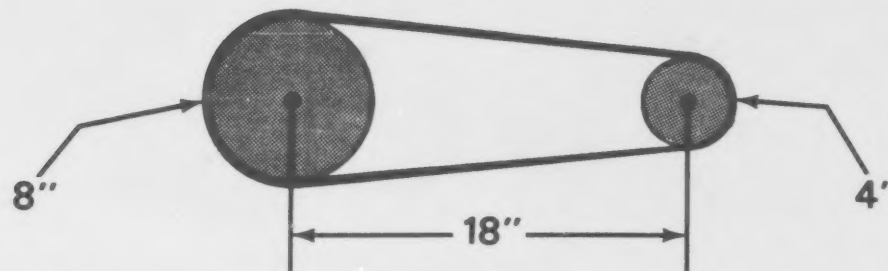
717

Adjustable Pulleys



Determining the Length of a Flat Belt

1. Add together the diameters of the 2 pulleys.
2. Divide this sum by 2 and multiply the quotient by 3.
3. To this product, add twice the distance between the centers of the two pulley shafts.



Example:

1. $8'' + 4'' = 12''$

2. $12'' \div 2 = 6''$ and $6'' \times 3 = 18''$

3. $18'' + 18'' + 18'' = 54''$

750

751

Determining the Length of a V-Belt



L = Length of Belt

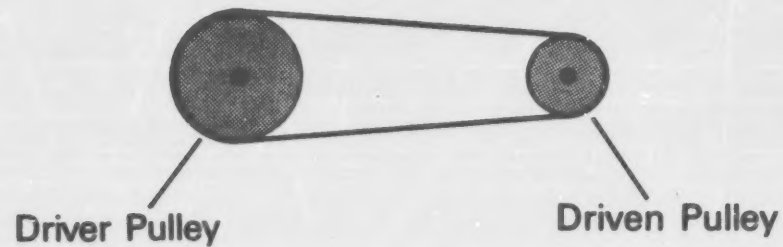
C = Distance Between Centers of Sheaves

D = Outside Diameter of Large Sheaves

d = Outside Diameter of Small Sheaves

$$L = 2C + 1.57 (D + d) + \frac{(D - d)^2}{4C}$$

Determining Pulleys Sizes and Speeds



D = Diameter of Driver Pulley

S = Speed of Driver Pulley

d = Diameter of Driven Pulley

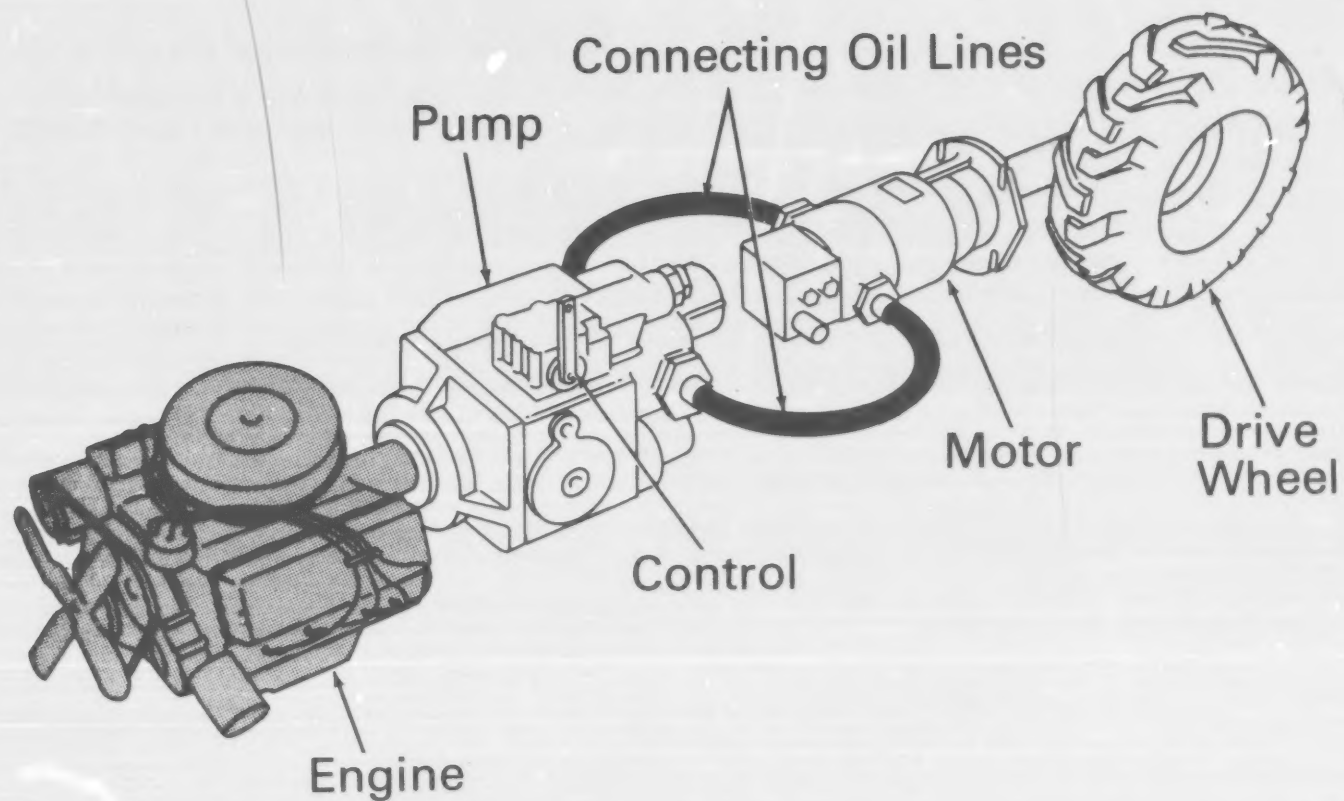
s = Speed of Driven Pulley

754

$$D \times S = d \times s$$

755

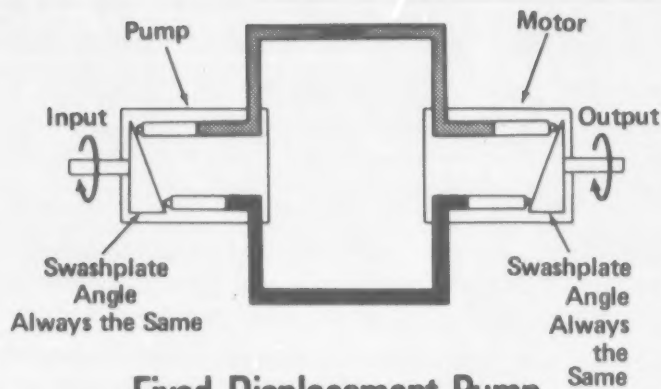
Hydrostatic Drive



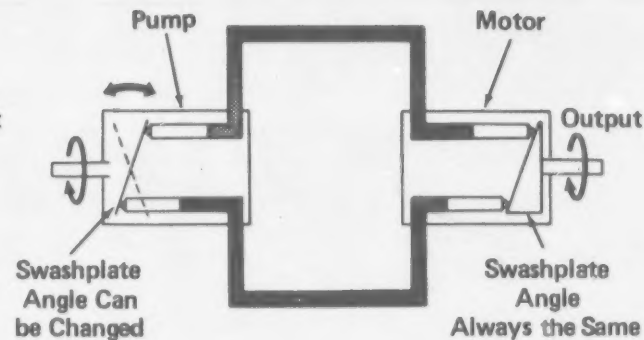
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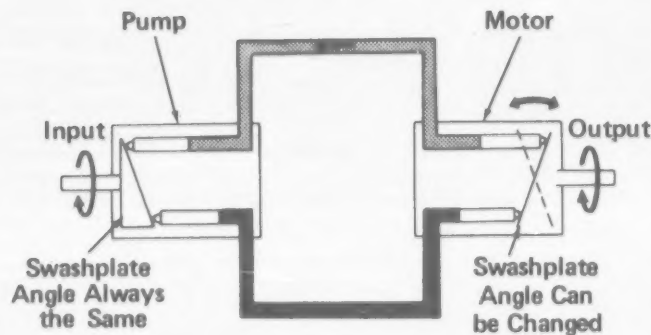
Hydrostatic Drives



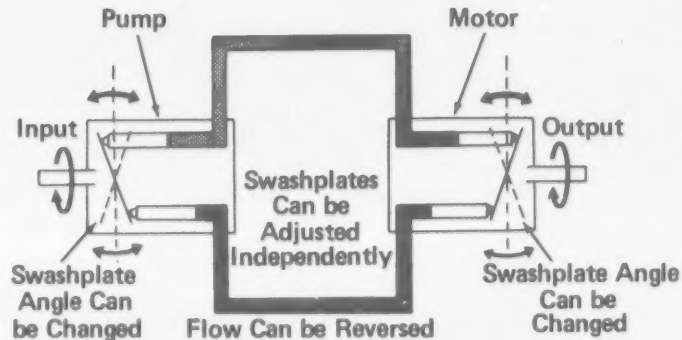
**Fixed Displacement Pump
Fixed Displacement Motor**



**Variable Displacement Pump
Fixed Displacement Motor**



**Fixed Displacement Pump
Variable Displacement Motor**



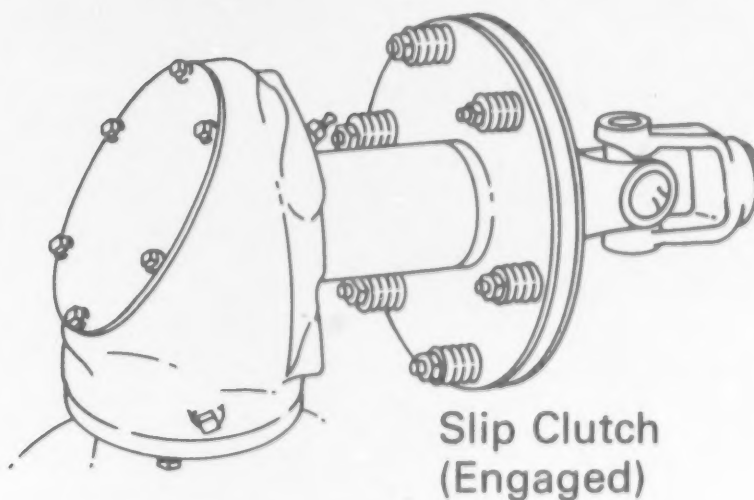
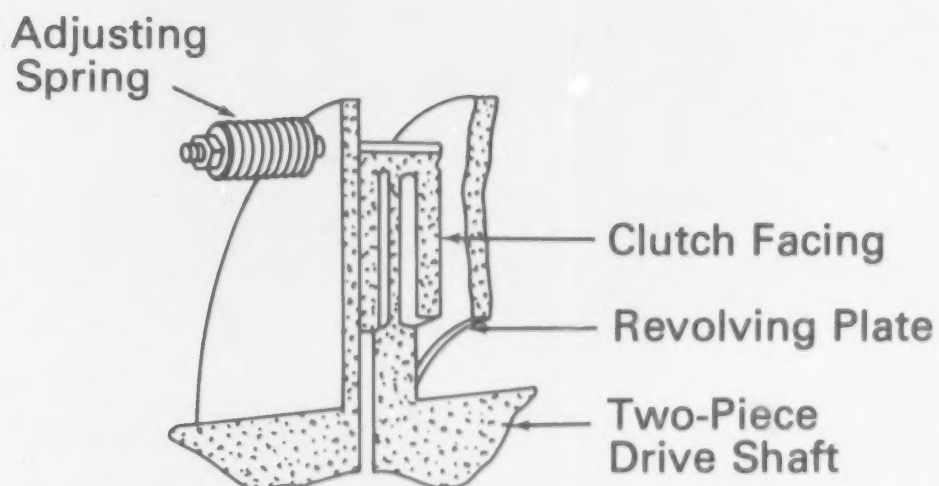
**Variable Displacement Pump
Variable Displacement Motor**

759

Courtesy DEERE & CO., MOLINE, IL

Safety Release Mechanisms

Slip Clutches



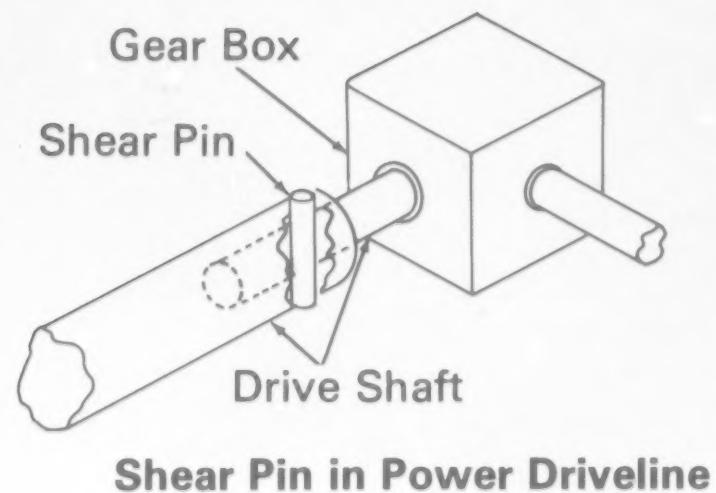
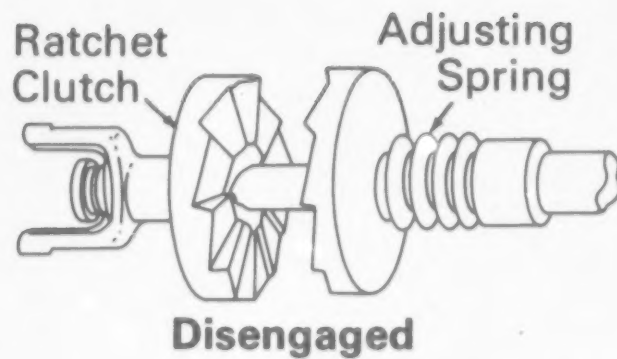
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Courtesy DEERE & CO., MOLINE, IL

Safety Release Mechanisms

(Continued)

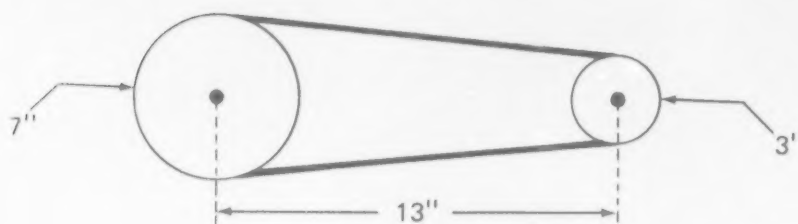
Jump Clutches



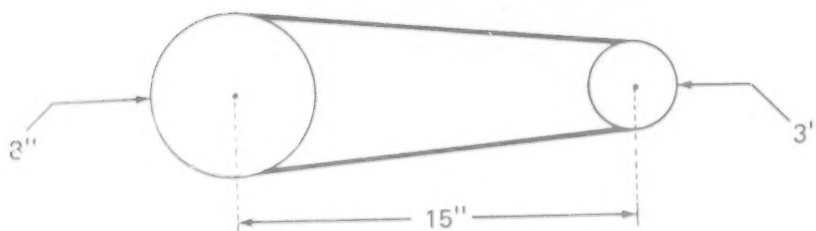
SPECIAL DRIVES
UNIT IX

ASSIGNMENT SHEET #1--COMPUTE THE LENGTH OF A FLAT BELT

Directions: Use the sizes and dimensions given to compute the length of the flat belts in each of the following illustrations; show your complete calculations beside each illustration.

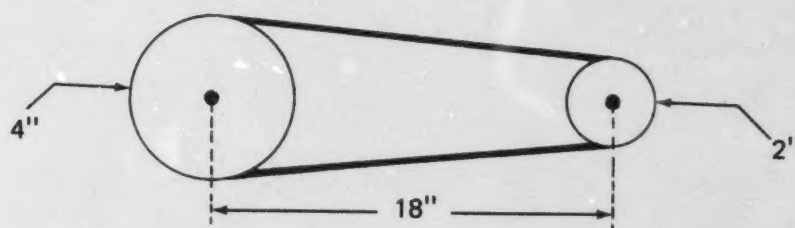


a. _____

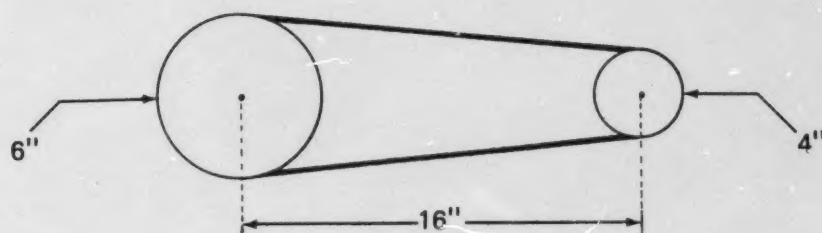


b. _____

ASSIGNMENT SHEET #1



c. _____

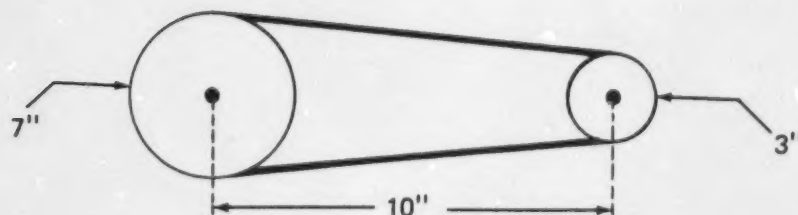


d. _____

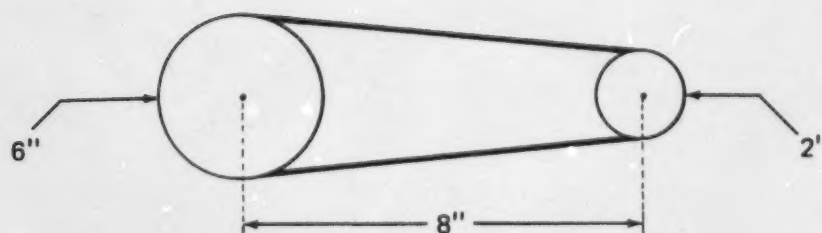
SPECIAL DRIVES
UNIT IX

ASSIGNMENT SHEET #2--COMPUTE THE LENGTH OF A V-BELT

Directions: Use the sizes and dimensions given to compute the length of the V-belts in each of the following illustrations; show your complete calculations beside each illustration.

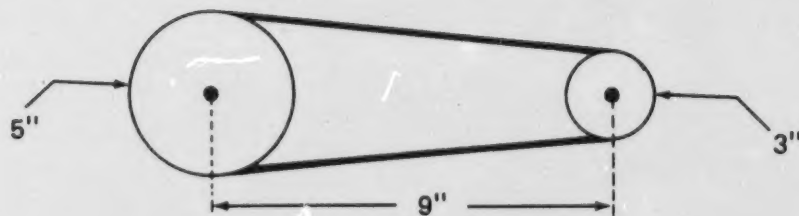


a. _____

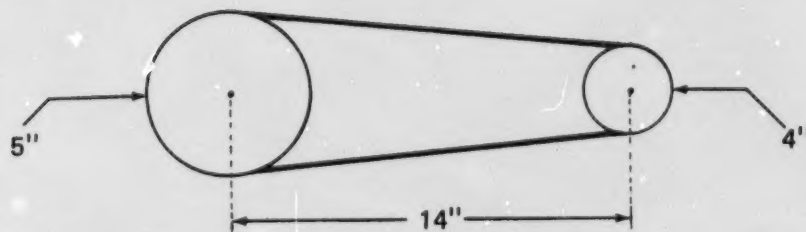


b. _____

ASSIGNMENT SHEET #2



c. _____



d. _____

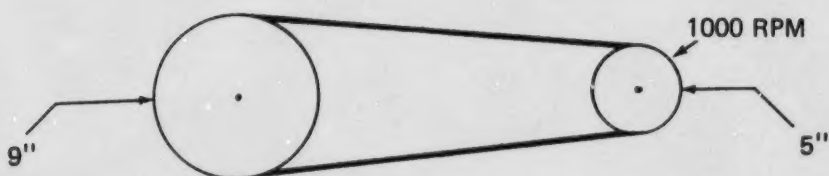
SPECIAL DRIVES
UNIT IX

ASSIGNMENT SHEET #3-COMPUTE PULLEY SIZE AND SPEED

Directions: Use the technical information given to compute pulley sizes and speeds in the following illustrations; show your complete calculations beside each illustration.

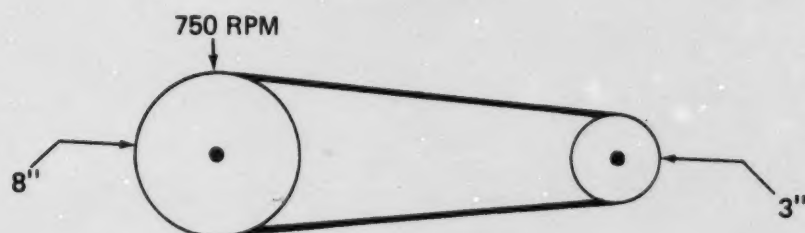


a. $s =$ _____



b. $s =$ _____

ASSIGNMENT SHEET #3



c. $s =$ _____



d. $s =$ _____

SPECIAL DRIVES
UNIT IX

ANSWERS TO ASSIGNMENT SHEETS

Assignment Sheet #1

- a. 41"
- b. 46.5"
- c. 45"
- d. 47"

Assignment Sheet #2

- a. 37.6"
- b. 30.125"
- c. 32.05"
- d. 43.767"

Assignment Sheet #3

- a. 600 RPM
- b. 555.56 RPM
- c. 2000 RPM
- d. 533.33 RPM

SPECIAL DRIVES UNIT IX

JOB SHEET #1--TROUBLESHOOT CHAIN DRIVES

I. Tools and materials

- A. Creeper
- B. Light
- C. Tape measure

II. Procedure

- A. Identify problems
- B. List possible causes
- C. Troubleshoot possible causes
- D. Complete troubleshooting checklists

(CAUTION: When troubleshooting, keep hands and clothing away from moving chains.)

III. Troubleshooting checklists

A. Problem: Excessive noise

Possible causes

- 1. Sprocket misalignment
- 2. Wrong chain tension
- 3. Improper chain lubrication
- 4. Loose castings or bearings
- 5. Worn sprockets
- 6. Wrong chain pitch

OK	Corrected	Other Observations

(NOTE: The column "Other Observations" should be used when a condition requires a major repair, a replacement part, or technical attention that requires special expertise; other columns should be checked and dated as appropriate.)

JOB SHEET #1

B. Problem: Chain climbing sprockets

Possible causes	OK	Corrected	Other Observations
1. Wrong chain			
2. Worn chain			
3. Lack of chain wrap on sprockets			
4. Too much chain slack			
5. Material build-up in sprocket tooth pockets			
6. Worn sprockets			

C. Problem: Broken pins, bushings, or rollers

Possible causes	OK	Corrected	Other Observations
1. Chain running too fast			
2. Slack or sudden loads			
3. Material build-up in sprocket tooth pockets			
4. Improper lubrication			
5. Chain or sprocket corrosion			
6. Wrong chain			
7. Worn sprockets			

JOB SHEET #1

D. Problem: Chain clinging to sprockets

Possible causes

1. Wrong chain
2. Worn sprockets
3. Heavy or tacky lubricant
4. Excessive slack
5. Material build-up in sprocket tooth pockets

OK	Corrected	Other Observations

E. Problem: Chain whipping

Possible causes

1. Too much slack in chain
2. High pulsating load
3. Stiff chain joints
4. Uneven wear on chain
5. New link in chain

OK	Corrected	Other Observations

F. Problem: Chains getting stiff

Possible causes

1. Lack of lubricant
2. Corrosion
3. Excessive load
4. Material build-up in chain joints
5. Peeling of side plate edges
6. Misalignment

OK	Corrected	Other Observations

JOB SHEET #1

G. Problem: Broken sprocket teeth

Possible causes	OK	Corrected	Other Observations
1. Obstruction or foreign material			
2. Excessive shock loads			
3. Chain climbing sprocket teeth			

H. Problem: Failure of chain fasteners

Possible causes	OK	Corrected	Other Observations
1. Vibration			
2. Obstructions striking fasteners			
3. Improperly installed fasteners			

I. Problem: Drives running too hot

Possible causes	OK	Corrected	Other Observations
1. Chain running too fast			
2. Lack of lubrication			
3. Immersed too deep in oil bath			
4. Chain shafts rubbing against obstruction			

SPECIAL DRIVES UNIT IX

JOB SHEET #2--TROUBLESHOOT BELT DRIVES

I. Tools and materials

- A. Belt tension gauge
- B. Light
- C. Straight edge

II. Procedure

- A. Identify problems
- B. List possible causes
- C. Troubleshoot possible causes
- D. Complete troubleshooting checklists

(CAUTION: When troubleshooting, keep hands and clothing away from moving belts.)

III. Troubleshooting checklists

A. Problem: Belts turning over in sheaves

Possible causes	OK	Corrected	Other Observations
1. Misalignment of sheaves and shafts			
2. Worn sheave grooves			
3. Misalignment of idler sheaves			
4. Belt damage from wrong installation			

(NOTE: Use straight edge to check sheave alignment; check and date appropriate columns, and use "Other Observations" column to note special problems.)

JOB SHEET #2

B. Problem: Belt squeaks

Possible causes

1. Too high starting load
2. Improper belt tension
3. Overload
4. Worn belt

OK	Corrected	Other Observations

C. Problem: Belt stretch

Possible causes

1. Drive operated under too much tension
2. Wrong belt
3. Poor storage in damp place

OK	Corrected	Other Observations

D. Problem: Belts breaking prematurely

Possible causes

1. Foreign material in sheaves
2. Extreme overload
3. Belt damaged during installation

OK	Corrected	Other Observations

E. Problem: Belt life too short

Possible causes

1. Worn sheaves
2. Oil or grease on belt
3. High temperature at sheaves
4. Belt rubbing a guard or belt guide
5. Belt slipping

OK	Corrected	Other Observations

SPECIAL DRIVES UNIT IX

JOB SHEET #3--TROUBLESHOOT GEAR DRIVES

- I. Tools and materials
 - A. Dial indicator
 - B. Light
 - C. Hand tachometer
- II. Procedure
 - A. Identify problems
 - B. List possible causes
 - C. Troubleshoot possible causes
 - D. Complete troubleshooting checklists
- III. Troubleshooting checklists
 - A. Problem: Gears with fins around edge of teeth

Possible causes

1. Too much backlash
2. Continues overloading
3. Intermittent overloading
4. Defective hardening of gears

OK	Corrected	Other Observations

(NOTE: Check and date appropriate columns, and use "Other Observations" column to note special problems.)

- B. Problem: Gears with teeth burned from overheating

Possible causes

1. Too little backlash
2. Overspeeding
3. Overloading
4. Lack of lubrication

OK	Corrected	Other Observations

JOB SHEET #3

C. Problem: Gears with scored teeth

Possible causes	OK	Corrected	Other Observations
1. Lack of lubrication			
2. Excessive speed			
3. Overloading			
4. Too little clearance			

D. Problem: Gears with abrasions or fine scratches on teeth

Possible causes	OK	Corrected	Other Observations
1. Dirt or grease in gears			
2. Metal particles in gears			

E. Problem: Gears with pitted or broken teeth

Possible causes	OK	Corrected	Other Observations
1. Overloading			
2. Too much backlash			
3. Shock loading			

SPECIAL DRIVES
UNIT IX

JOB SHEET #4--TROUBLESHOOT HYDROSTATIC DRIVES

- I. Tools and materials
 - A. Basic hand tools
 - B. Pressure gauges
 - C. Hydraulic flow meter
 - D. Shop towels
 - E. Cleaning solvent
- II. Procedure
 - A. Identify problems
 - B. List possible causes
 - C. Troubleshoot possible causes
 - D. Complete troubleshooting checklists
- III. Troubleshooting checklists
 - A. Problem: Drive not moving in forward or reverse drive

Possible causes

- 1. Improper fluid level
- 2. Fluid leaks
- 3. Clogged oil filter and screen
- 4. Binding control linkage
- 5. Slipping coupling from engine to pump
- 6. Slipping coupling from motor to gear train

OK	Corrected	Other Observations

JOB SHEET #4

Possible causes

7. Low or no charge pressure (Use gauge to check charge pressure control valve, check for binding pump drive, and for oil line restrictions)
8. Low or fluctuating charge pressure (Bleed air from system, check for damaged pressure control valve, check for faulty check valves)

OK	Corrected	Other Observations

B. Problem: Hydrostatic drive moves in only one direction

Possible causes

1. Faulty control linkage
2. High pressure relief valve stuck open
3. Faulty check valves
4. Faulty directional control valve

OK	Corrected	Other Observations

C. Problem: Hydrostatic drive operating hot

Possible causes

1. Improper oil level
2. Clogged air passage in oil cooler
3. Fan belt to oil cooler fan worn or improperly adjusted

OK	Corrected	Other Observations

JOB SHEET #4

D. Problem: Loss of acceleration and power

Possible causes	OK	Corrected	Other Observations
1. Internal leaks			
2. High pressure relief valve stuck			
3. Internal damage in pump or motor			

E. Problem: Sluggish acceleration or deceleration

Possible causes	OK	Corrected	Other Observations
1. Hydraulic system (may need bleeding)			
2. Control orifice partially blocked			
3. Internal damage in pump or motor			

SPECIAL DRIVES UNIT IX

JOB SHEET #5--TROUBLESHOOT SAFETY MECHANISMS

I. Tools and materials

- A. Basic hand tools
- B. Cleaning solvent
- C. Compressed air

II. Procedure

- A. Identify problems
- B. List possible causes
- C. Troubleshoot possible causes
- D. Complete troubleshooting checklists

III. Troubleshooting checklists

A. Problem: Slip clutch continually slipping

Possible causes

- 1. Weak spring tension
- 2. Worn belleville washer
- 3. Oiled or glazed clutch linings
- 4. Improper assembly
- 5. Failure in working element

OK	Corrected	Other Observations

B. Problem: Slip clutch not slipping under excessive load

Possible causes

- 1. Stuck facings
- 2. Improper spring tension
- 3. Improper assembly

OK	Corrected	Other Observations

JOB SHEET #5

C. Problem: Jump clutch slipping

Possible causes

1. Improper spring tension
2. Worn ratchet teeth
3. Excessive lubricant on ratchet teeth
4. Dirt build-up in ratchet teeth
5. Overload in working element
6. Stuck working element

OK	Corrected	Other Observations

D. Problem: Jump clutch not slipping under overload

Possible causes

1. Improper spring tension
2. Frozen ratchet due to rust or corrosion
3. Dirt preventing operation of spring release or ratchet
4. Internal shaft frozen to external shaft

OK	Corrected	Other Observations

E. Problem: Shear pin continually shearing off

Possible causes

1. Wrong shear pin or bolt
2. Overload in working element

OK	Corrected	Other Observations

F. Problem: Shear pin not shearing when overloaded

Possible causes

1. Wrong shear pin or bolt
2. Internal shaft frozen to external shaft

OK	Corrected	Other Observations

SPECIAL DRIVES UNIT IX

NAME _____

TEST

1. Match the terms on the right with their correct definitions.

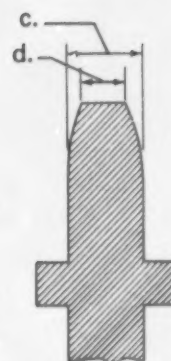
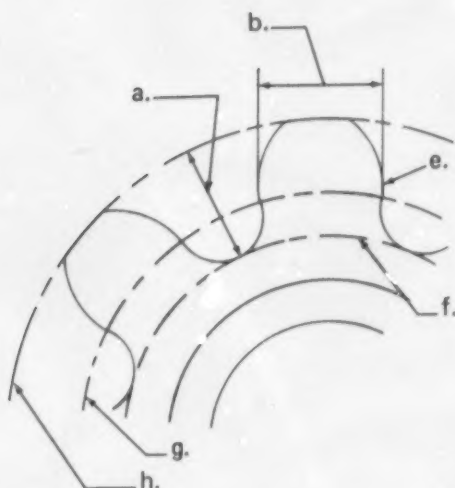
- | | |
|--|--------------------------|
| _____ a. A series of formed links, either open or closed, which can be detached and are either malleable cast iron or pressed steel | 1. ID |
| _____ b. Made up of alternate roller links and pin links with pins and free rolling bushings | 2. Roller chain |
| _____ c. A series of flat metal links, with a tooth shape at each end, connected by pins to form a flexible continuous chain | 3. Sprocket pitch |
| _____ d. Distance from the center of one pin to the center of the next pin | 4. Detachable-link chain |
| _____ e. Distance between one point on a sprocket tooth and the corresponding point on the next tooth | 5. Silent chain |
| _____ f. Adjusting or positioning parts to bring into line | 6. Chain pitch |
| _____ g. When bearings are not on the same center line with good functional or working limits | 7. Alignment |
| _____ h. Inside diameter | 8. V-belt |
| _____ i. Outside diameter | 9. OD |
| _____ j. Drives that change a rotary motion to a linear motion | 10. Reciprocating drives |
| _____ k. Effort which elongates or stretches a material | 11. Flat belt |
| _____ l. A belt of flat construction used where pulleys are far apart and high power is needed for a separate machine | 12. Misalignment |
| _____ m. A belt of V construction used for driving light loads between short-range pulleys; the load is carried on the sides of the belt | 13. Tension |
| _____ n. Contact between belt and pulley | 14. Gear drive |
| _____ o. Slight loss of speed between the drive and driven pulleys | 15. Belt creep |

- _____ p. The slight stretching of the belt as it runs over the pulley
- _____ q. A drive using fluid under pressure to transmit engine power to the driven unit
- _____ r. Type of drive in which a system of gear arrangements is used to transmit power
- _____ s. The quantity of fluid a pump can move during each revolution
- _____ t. Feet per minute
16. Hydrostatic drive
17. Belt slip
18. Arc
19. Displacement
20. FPM
2. List three types of chain drives.
- a. _____
- b. _____
- c. _____
3. Complete the following statements concerning detachable-link chains.
- a. Series of formed links
- b. _____
- c. Larger plain chains are of _____ construction
- d. Low speed use
- e. Open plain chains used in _____
- f. Closed pintle chains used in _____
4. Select true statements concerning roller chains by placing an "X" in the appropriate blanks.
- _____ a. May be installed in multiple strands for heavier loads
- _____ b. Have less vibration than plain chains
- _____ c. Good for low speed heavy loads with sprockets close together
- _____ d. Made up of pin bushing and roller for less wear
- _____ e. Two types of roller chains, single pitch and double pitch
5. Select true statements concerning silent chains by placing an "X" in the appropriate blanks.
- _____ a. Sprockets are similar to gears in appearance
- _____ b. Quieter operation but more vibration

- ☐ c. Can operate at higher speeds
 - ☐ d. Some have links with teeth on both sides so that over-and-under drives can be used
 - ☐ e. Not used as timing chains
6. Complete the following statements concerning characteristics of detachable-link chains.
- a. Used at speeds up to 500 RPM
 - b. Low in cost
 - c. Ideal for _____ work
 - * d. Provide better wear under dirty conditions
 - e. Malleable cast iron chain more resistant to corrosion than _____
 - f. Pressed steel has lower initial cost
7. Select true statements concerning characteristics of standard pitch roller chains by placing an "X" in the appropriate blanks.
- ☐ a. Satisfactory at speeds of 100 FPM to 4500 FPM depending on pitch
 - ☐ b. As speed increases the pitch also increases
 - ☐ c. May be 98 to 99 percent efficient under ideal conditions
 - ☐ d. Oil bath lubrication desired for high speed drives
 - ☐ e. Sprockets are driven from only one side of roller chain
8. Select true statements concerning characteristics of double pitch roller chains by placing an "X" in the appropriate blanks.
- ☐ a. Satisfactory for small sprocket speeds of up to 600 RPM
 - ☐ b. Similar to standard pitch roller chains except is half the pitch of standard
9. Complete the following statements concerning characteristics of silent chains.
- a. More satisfactory at _____ than roller chains
 - b. Have practically no _____
 - c. Most commonly used in final drives of tractors and transfer cases for four wheel drive vehicles

10. Complete the following statements concerning principles of chain drives.
- a. Chain drives consist of one or more sprockets and an endless chain
 - b. The links of the chain mesh with the teeth of the sprocket and maintain a constant speed ratio between _____
 - c. Sprockets on the same side of a chain turn in the same direction
 - d. Sprockets on the opposite side of the chain turn in opposite direction
 - e. Sprockets should always be no smaller than _____ to prevent excessive wear
 - f. If the chain has even number of pitches, the sprockets have to have an odd number of teeth or vice versa
 - g. The smaller the sprocket, the _____ wear on chain and sprocket
11. Select true statements concerning the alignment of sprocket shafts and sprockets by placing an "X" in the appropriate blanks.
- _____ a. Level each shaft with machinist's level or protractor
 - _____ b. Align all shafts perpendicular to each other by making sure the distance between the shafts is equal on both sides of the sprockets
 - _____ c. Align sprockets with straight edge on the finished surfaces on the sides of the sprockets
12. Select true statements concerning adjustment of chain tension by placing an "X" in the appropriate blanks.
- _____ a. Horizontal and inclined drives should have slack on both sides
 - _____ b. Vertical drives, and shock loading or reversible rotation drives' chains should be almost taut
13. Complete the following list of methods of adjusting chain tension.
- a. Moveable sprocket shafts
 - b. _____
 - c. Adjustable shoe

14. Identify parts of a chain sprocket.



Cross Section
of Sprocket

- | | |
|----------|----------|
| a. _____ | e. _____ |
| b. _____ | f. _____ |
| c. _____ | g. _____ |
| d. _____ | h. _____ |

15. Select true statements concerning stretched chain by placing an "X" in the appropriate blanks.

- ____ a. Adjuster has reached end of travel
- ____ b. Chain begins to ride on the tips of the sprocket teeth

16. Complete the following statements concerning reasons for lubrication of chains.

- a. Reduces _____
- b. Protects against corrosion
- c. Prevents _____
- d. Prevents seizing of pins and bushings

17. List three methods of lubricating chains.

- a. _____
- b. _____
- c. _____

18. Select true statements concerning repair of chain drives by placing an "X" in the appropriate blanks.

- _____ a. Grind off heads of link pins or remove keys
- _____ b. Drive out the two pins of the link evenly
- _____ c. Reverse sprockets, if design permits
- _____ d. Do not install new chain on worn sprockets
- _____ e. New chain links may be added to worn chain

19. Complete the following statements concerning cleaning chains.

- a. Wash chain in cleaning solvent
- b. _____
- c. Soak chain in _____
- d. Hang chain to let excess oil drain off

20. Name three types of belts.

- a. _____
- b. _____
- c. _____

21. Name four factors governing the ability of belts to transmit power.

- a. _____
- b. _____
- c. _____
- d. _____

22. List three forms of belt drive arrangements.

- a. _____
- b. _____
- c. _____

23. Complete the following measurements of belt sections used on combines.

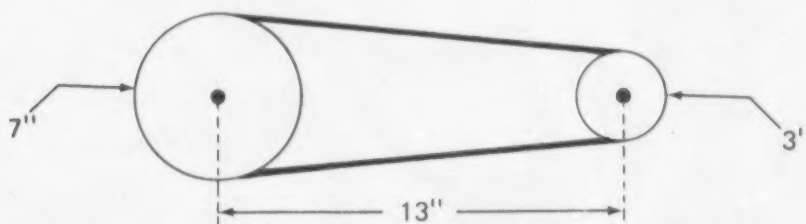
- a. $1/2$ X _____
- b. $21/32$ X _____
- c. $7/8$ X _____
- d. $1\ 1/4$ X _____
- e. $1\ 3/4$ X _____

24. Select true statements concerning adjustable pulleys by placing an "X" in the appropriate blanks.

(NOTE: A statement is true only if all parts of the statement are true.)

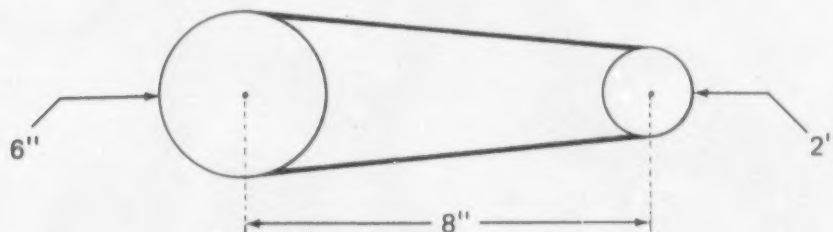
- _____ a. Used to adjust belt tension
- _____ b. Used to change belt speed
 - 1) Moving belt in on drive pulley and out on driven pulley increases speed of driven pulley
 - 2) Moving belt out on drive pulley or in on driven pulley decreases driven pulley speed

25. Determine the length of the flat belt in the following illustration.



Answer: _____

26. Determine the length of the V-belt in the following illustration.



Answer: _____

27. Determine pulley sizes and speeds in the following illustration.



Answer: _____

28. Select true statements concerning belt tension by placing an "X" in the appropriate blanks.

(NOTE: A statement is true only if all parts of the statement are true.)

_____ a. Results of too much tension

- 1) Broken belt
- 2) Burned spots
- 3) Excessive cover wear
- 4) Overheating of belt and pulley

_____ b. Results of too little tension

- 1) Belt heating
- 2) Excessive stretch
- 3) Damage to bearings in drive and driven units
- 4) Damage to pulleys

_____ c. Correct tension on V-belt

- 1) Belt should show springiness when hit with the hand
- 2) Belts should not vibrate like a rubber band
- 3) Properly adjusted, a belt should deflect about one thickness of the belt at a point midway between sheaves
- 4) Belt should be readjusted after 1 hour of operation and checked periodically

29. Select true statements concerning belt care and maintenance by placing an "X" in the appropriate blanks.

(NOTE: A statement is true only if all parts of the statement are true.)

_____ a. Problems caused by oil and grease and their solutions

- 1) Causes belts to become soft
- 2) Causes belts to slip
- 3) Clean with soft cloth soaked in solvent

_____ b. Problems caused by heat over 120° F

- 1) Belts may harden
- 2) Belts may crack
- 3) Belts may stretch

_____ c. Matching of belts

- 1) If one belt in a set needs replaced, replace only that belt
- 2) Never use belts manufactured by different companies in the same set

_____ d. A belt should seat 1" above or below outer edge of sheave

30. Complete the following statements concerning maintenance of pulleys or sheaves.

a. Worn sheave grooves can be caused by:

- 1) Dust
- 2) Corrosion from _____

b. Shiny sheave groove bottom can be caused by:

- 1) Worn belt
- 2) _____
- 3) Wrong sheave
- 4) Wrong belt

c. Wobbling sheaves can be caused by:

- 1) _____
- 2) Bent sheave
- 3) Worn or damaged shaft bearings
- 4) Worn bore in sheave

31. Match types of gear drives on the right with their uses.

- | | | |
|----------|--|----------------|
| _____ a. | 1) Used in screw jacks | 1. Worm gears |
| | 2) Used in machine feed | 2. Bevel gears |
| _____ b. | 1) Used to change direction | 3. Screw gears |
| | 2) Used in ring gear and pinion | |
| _____ c. | 1) Used in steering gears | |
| | 2) Used in winch drives | |
| | 3) Used in applications with high speed input and low speed output | |

32. Complete the following statements concerning methods of lubricating gears.

- Splash pan, which the gears run through
- _____ by brushing or squirting lubricant on gears
- Automatic lubrication by _____
- Forced lubrication by means of a pump

33. Select true statements concerning gear backlash by placing an "X" in the appropriate blanks.

(NOTE: A statement is true only if all parts of the statement are true.)

- Too much gear backlash can be caused by any of the following:
 - Worn gears
 - Improper meshing of teeth
 - Worn bearings
 - Improper bearing adjustment
- Too much backlash results in severe gear teeth impact causing damage to gear teeth
- Gear backlash is adjusted either by shims or by bearing preload
- Gear backlash in some cases is preset at manufacture by gear and bearing arrangement

34. Match types of reciprocating drives on the right with their characteristics.

- | | |
|---|---|
| <p>_____ a. 1) Crankwheel has lever mounted off center</p> <p>2) As wheel turns one revolution, lever makes two strokes</p> | <p>1. Crankarm and lever drive</p> <p>2. Cam drives</p> |
| <p>_____ b. 1) Operates like a crankshaft and rod assembly in an engine</p> <p>2) Has a flywheel or counterbalance to offset the inertia of the sudden changes in direction</p> <p>3) The direction of the counterbalance is always the opposite of the pitman or lever</p> | <p>3. Crankwheel and lever</p> |
| <p>_____ c. 1) Change rotary motion to reciprocating motion by use of a cam and cam follower</p> <p>2) Cam follower always returns to same starting point</p> <p>3) Action may be simple direct motion, complicated motion, or delayed motion</p> <p>4) Cam drives may use a spring load, gravity, or a track to return them to their starting position</p> | |

35. Select true statements concerning maintenance of reciprocating drives by placing an "X" in the appropriate blanks.

(NOTE: A statement is true only if all parts of the statement are true.)

- _____ a. Lubrication is the key to good operation of all mechanical drives; any moving part that contacts another part should be lubricated
- _____ b. Points of maintenance
- 1) Bearings should be kept lubricated and checked for wear or damage periodically
 - 2) Cam tracks or cam surfaces require greasing for smooth operation and minimum wear
 - 3) Hinged areas need lubrication
 - 4) Enclosed drives should have oil level checked periodically
 - 5) Refer to machine operator's manual for proper lubrication periods and type of lubricants

36. Match hydrostatic drives on the right with their characteristics.

- | | |
|---|--|
| <p>_____ a. 1) Constant input speed gives constant horsepower and torque at the output</p> <p>2) Input speed varies; output horsepower and speed will vary, but torque will remain the same</p> <p>3) When both pump and motor are in this arrangement they act as a gear drive</p> | <p>1. Fixed displacement pump with fixed displacement motor</p> <p>2. Variable displacement pump with fixed displacement motor</p> |
| <p>_____ b. 1) Pump output is variable, motor output speed is variable and torque output is constant for any given pressure</p> <p>2) This type drive gives variable speed and constant torque</p> | <p>3. Variable displacement pump with variable displacement motor</p> <p>4. Fixed displacement pump with variable displacement motor</p> |
| <p>_____ c. 1) Output speed controlled by changing the motor displacement</p> <p>2) Motor displacement decreases; output speed increases, and torque decreases</p> <p>3) When balanced, constant horsepower output is obtained</p> | |
| <p>_____ d. 1) Output of both constant torque and constant horsepower</p> <p>2) Most flexible drive but also is the most difficult to control</p> | |

37. Select true statements concerning reversing hydrostatic drives by placing an "X" in the appropriate blanks.

- _____ a. Reversing output shaft of motor can be done by shifting either the pump or motor swashplates
- _____ b. In forward the swashplate is vertical and no oil is pumped
- _____ c. In neutral, the swashplate is tilted and oil is pumped in one direction
- _____ d. In reverse, the swashplate is tilted the opposite way and oil is pumped the opposite direction reversing the motor output

38. Complete statements concerning maintenance of hydrostatic drives.

- a. Clean unit before removing components
- 1) Steam clean complete area around component to be worked on
 - 2) If steam cleaning is unavailable use a cleaning solvent
 - 3) Prevent _____ from entering system when steam cleaning

b. Precautions to take before repairing pump or motor

- 1) Seal all lines and fittings with plastic bags or plugs as lines are removed
- 2) Have a container of clean solvent to wash parts in
- 3) Have clean, dust free work area
- 4) _____
- 5) Have a container of clean petroleum jelly to lubricate surfaces where needed
- 6) Have new o-rings and gaskets
- 7) _____

39. Select true statements concerning testing hydrostatic drives by placing an "X" in the appropriate blanks.

- _____ a. Test charging and operating oil pressures
- _____ b. Test for oil flow rate and oil temperature
- _____ c. Use the proper test equipment and procedures as given in the machine technical manual

40. List the functions of a safety release mechanism.

- a. _____
- b. _____

41. Match types of safety release mechanisms on the right with their descriptions.

- | | | |
|----------|---|------------------|
| _____ a. | 1) Installed in drive line | 1. Shear pin |
| | 2) Works by means of friction discs and springs | 2. Slip clutches |
| | 3) Obstruction in machine overcomes friction clutch facings, preventing damage to machine | 3. Jump clutches |
| | 4) Tension can be adjusted at the springs | |
| _____ b. | 1) Installed in drive line | |
| | 2) Have ratchet teeth and spring tension | |
| | 3) In case of overload, the spring tension is overcome and ratchet slips, disengaging the power train | |
| | 4) Tension should be adjusted at spring | |

- c.
 - 1) Works on stress principle
 - 2) The harder the pin the more force it takes to shear
 - 3) When an obstruction enters the machine, the pin will shear, protecting the machine
 - 4) Shear pins are inexpensive
 - 5) When pin shears, the machine is inoperative until pin is replaced
- 42. Complete the following statements concerning maintenance of safety mechanisms.
 - a. Lubrication of safety mechanisms
 - 1) Light coat of oil on faces of clutches to prevent sticking
 - 2) Too much oil causes slipping
 - 3) _____
 - 4) Lubricate shafts where they come together
 - b. Follow machine specifications for adjustment of safety mechanisms and proper

- 43. Compute the length of a flat belt.
- 44. Compute the length of a V-belt.
- 45. Compute pulley size and speed.
- 46. Demonstrate the ability to:
 - a. Troubleshoot chain drives.
 - b. Troubleshoot belt drives.
 - c. Troubleshoot gear drives.
 - d. Troubleshoot hydrostatic drives.
 - e. Troubleshoot safety mechanisms.

(NOTE: If these activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

SPECIAL DRIVES
UNIT IX

ANSWERS TO TEST

- | | | | | | | | | | |
|-------|---|----|----|----|----|----|----|----|----|
| 1. a. | 4 | e. | 3 | i. | 9 | m. | 8 | q. | 16 |
| b. | 2 | f. | 7 | j. | 10 | n. | 18 | r. | 14 |
| c. | 5 | g. | 12 | k. | 13 | o. | 17 | s. | 19 |
| d. | 6 | h. | 1 | l. | 11 | p. | 15 | t. | 20 |
2. a. Detachable-link chain
b. Roller chain
c. Silent chain
3. b. Detachable links
c. Pintle
e. Light loads
f. Heavier loads
4. a, b, d, e
5. a, c, d
6. c. Conveyor or elevator
e. Steel
7. a, c, d
8. a
9. a. Higher speeds
b. Sliding action
10. b. Drive and driven sprockets
e. Ten teeth
g. More
11. a, c
12. b
13. b. Adjustable idler sprockets
14. a. Tooth height
b. Tooth thickness
c. Tooth width
d. Point width
e. Tooth face
f. Base circle
g. Pitch circle
h. Outside circle

15. a, b
16. a. Wear
b. Galling
17. Any three of the following:
- a. Manual lubrication
 - b. Drip lubrication
 - c. Oil bath lubrication
 - d. Disc lubrication
 - e. Oil stream lubrication
18. a, b, c, d
19. b. Drain and dry chain
c. Oil
20. Any three of the following:
- a. Flat belt
 - b. V-belt
 - c. Round belt
 - d. Polygrooved or ribbed belt
21. a. Tension of belt
b. Friction of belt to pulley
c. Speed of belt
d. Belt wrap on pulley
22. Any three of the following:
- a. Open
 - b. Turned
 - c. Crossed
 - d. Serpentine
 - e. Mule
23. a. 5/16
b. 13/32
c. 17/32
d. 3/4
e. 25/32
24. a
25. 41"
26. 30.125"
27. 600 RPM
28. c

29. a, b
30. a. Moisture and chemicals in the air
b. Worn sheave
c. Bent shaft
31. a. 3
b. 2
c. 1
32. b. Hand lubrication
c. Drip oiler
33. a, b, c, d
34. a. 3
b. 1
c. 2
35. a, b
36. a. 1
b. 2
c. 4
d. 3
37. a, d
38. a. 3) Water
b. 4) Have a container of clean transmission fluid to lubricate parts as they are assembled
7) Have new or clean oil for system
39. a, b, c
40. a. Relieves shock on the power source
b. Protects machine doing the work
41. a. 2
b. 3
c. 1
42. a. Lubricate springs
b. Shear pins

- 43. Evaluated to the satisfaction of the instructor
- 44. Evaluated to the satisfaction of the instructor
- 45. Evaluated to the satisfaction of the instructor
- 46. Performance skills evaluated to the satisfaction of the instructor